

**Studies on Caecilians (Amphibia : Gymnophiona : Ichthyophiidae)
North East India with description of three new species of *Ichthyophis*
from Garo hills, Meghalaya and additional information on
Ichthyophis garoensis Pillai and Ravichandran, 1999**

**ROSAMMA MATHEW
AND
NIBEDITA SEN**



OCCASIONAL PAPER NO. 309

RECORDS OF THE ZOOLOGICAL SURVEY OF INDIA

**Studies on Caecilians (Amphibia : Gymnophiona : Ichthyophiidae)
of North East India with description of three new species of
Ichthyophis from Garo Hills, Meghalaya and additional information
on *Ichthyophis garoensis* Pillai and Ravichandran, 1999**

**ROSAMMA MATHEW
NIBEDITA SEN**

North Eastern Regional Centre, Zoological Survey of India, Risa Colony, Shillong-793003

Edited by the Director, Zoological Survey of India, Kolkata



**Zoological Survey of India
Kolkata**

CITATION

Mathew, R. and Sen, N. 2009. Studies on Caecilians (Amphibia : Gymnophiona : Ichthyophiidae) of North East India with description of three new species of *Ichthyophis* from Garo Hills, Meghalaya and additional information on *Ichthyophis garoensis* Pillai and Ravichandran, 1999. *Rec. zool. Surv. India, Occ. Paper No., 309* : 1-56. (Published by the Director, *Zool. Surv. India*, Kolkata)

Published : November, 2009

ISBN 978-81-8171-241-7

© Govt. of India, 2009

ALL RIGHTS RESERVED

- No part of this publication may be reproduced, stored in a retrieval system or transmitted in any form or by any means, electronic, mechanical, photocopying, recording or otherwise without the prior permission of the publisher.
- This book is sold subject to the condition that it shall not, by way of trade, be lent, resold hired out or otherwise disposed off without the publisher's consent, in any form of binding or cover other than that in which, it is published.
- The correct price of this publication is the price printed on this page. Any revised price indicated by a rubber stamp or by a sticker or by any other means is incorrect and should be unacceptable.

PRICE

Indian Rs. 200.00

Foreign : \$ 15; £ 10

Published at the Publication Division by the Director Zoological Survey of India, 234/4, AJC Bose Road, 2nd MSO Building, 13th floor, Nizam Palace, Kolkata - 700020 and printed at Power Printers, New Delhi - 110 002.

**RECORDS OF THE
ZOOLOGICAL SURVEY OF INDIA
OCCASIONAL PAPER**

NO. 309	2009	1-56
----------------	-------------	-------------

CONTENTS

INTRODUCTION	1
MATERIALS AND METHODS	2
ECOLOGY AND NATURAL HISTORY	2
Genus <i>Ichthyophis</i> Fitzinger, 1826	3
Key to the striped species of <i>Ichthyophis</i> of North East India	3
1. <i>Ichthyophis alfredii</i> sp. nov.	4
2. <i>Ichthyophis daribokensis</i> sp. nov.	8
3. <i>Ichthyophis nokrekensis</i> sp. nov.	13
4. <i>Ichthyophis garoensis</i> Pillai and Ravichandran, 1999	16
DISCUSSION	17
ACKNOWLEDGEMENTS	18
REFERENCES	19
Table-1. Different Morphological Counts and Measurements of <i>Ichthyophis alfredii</i> sp. nov. (Measurements expressed in Millimeter).	21
Table 2. Comparison of different morphological characters (mean value) of three new species with other related striped species of <i>Ichthyophis</i> from India (in percentage with relation to total length)	24
Table-3. Different morphological counts and measurements of <i>Ichthyophis daribokensis</i> sp. nov. (Measurements expressed in millimeter)	25
Table-4. Different morphological counts and measurements of <i>Ichthyophis nokrekensis</i> sp. nov. (measurements expressed in millimeter)	28
Table-5. Different morphological counts and measurements of <i>Ichthyophis garoensis</i> (measurements expressed in millimeter).	31
Table-6. Different morphological counts and measurements of juveniles of <i>Ichthyophis</i> <i>daribokensis</i> sp. nov. (measurements expressed in millimeter and percentage to total length)	33

Table-7. Mean value of different morphological counts and measurements of <i>I. alfredii</i> sp. nov., <i>I. daribokensis</i> sp. nov., <i>I. nokrekensis</i> sp. nov. and <i>I. garoensis</i> (measurements expressed in percentage to total length)	35
Table-8. Mean value of different morphological measurements of <i>I. alfredii</i> sp. nov., <i>I. daribokensis</i> sp. nov., <i>I. nokrekensis</i> sp. nov. and <i>I. kodaguensis</i> (measurements expressed in percentage to total length)	37
PLATES 1-XIII	41-56

INTRODUCTION

Caecilians or limbless amphibians fall under the order Gymnophiona of the class amphibia. The mostly fossorial and tropical Ichthyophiidae and its sister taxa Uraeotyphlidae are the only caecilian families restricted to Asia (Gower *et al.*, 2002). They are believed to have been dispersed from India to south east Asia. The latter with a single genus is restricted to the southern part of the Western Ghats. Ichthyophid taxonomy is not adequately established to enable a confident specific identification mostly because of their external similarity. There is no sexual dimorphism among them though in certain cases older females were significantly larger than males (Kupfe *et al.*, 2004). Morphological caecilian systematics, especially at low levels, has been dogged by a paucity of obvious external characters and a lack of understanding of their variabilities. According to Pillai and Ravichandran (1999), prior to Taylor's (1960-68) series of publications on the caecilian fauna of India, very little study was done on this group of animals in India. They wrote "hardly any work is being pursued in India which could boast of a rich complement of caecilian genera and species. Caecilian material available with the major taxonomic institutions in India is poor and unrepresentative. Caecilian collections are undoubtedly better in museums outside India where most of the type materials are deposited" Agreeing to the above statements and keeping in view of the above facts the authors took a passionate interest to collect and study these animals from Northeast India, particularly Meghalaya and specifically from Garo Hills. The outcome was heart warming: 36 specimens including 6 juveniles between April to June, 2008, from within a radius of less than 30 kms which formed the material for the present study. An additional survey in the study area in the last week of September, 2008 yielded 7 more adult and 19 juvenile specimens thereby making a total of 62 specimens including 25 juveniles. When compared to the 94 specimens representing 21 species studied by Pillai and Ravichandran (1999) this total is an achievement in itself.

Caecilians are popularly known as 'Chikil' to the people of Garo Hills. We took local assistance to guide us to possible locations for collection of material. During one such trips an energetic and enthusiastic guide took us to his village some 61 km away from Tura in south Garo Hills district. We crossed the swollen Dareng river in a small canoe and walked a kilometer to the Mitapgre village. On reaching the village our guide grabbed a spade and without wasting time set out to dig. And there one after another some twenty wriggling, red 'chikil' were collected. We shifted from place to place in search of different type of specimens. Our guide knew there were red, white and black 'chikil' It was only later that we could realize that the red wriggling 'chikil' were only fish of the variety Eel. Finally we got few white and black 'chikil' which turned out to be *Typhlops* and not Caecilians! Even the limbless lizard is a 'chikil' to a Garo.

The study area falling under the Nokrek Biosphere Reserve lies between N 25° 20'-N 25° 29' E 90° 13' E 90° 35' and comprises of hills, streams and rivers and is rather unpolluted with modern technological developments. The altitude varies from 341–1412 m and the climate is tropical monsoon type with high rainfall and humidity during monsoon (April to October). The temperature varies from 3°C to 30°C. The soil is loose, mostly red loam, acidic, poor in energy material and water holding capacity, and highly porous in nature. It contains high quantum of silica (93.2%). The traditional way of agriculture practice followed is shifting cultivation.

MATERIALS AND METHODS

Materials for the present study were collected from Nokrek Biosphere Reserve in East and West Garo Hills districts of Meghalaya between April to September, 2008. Type localities of *Ichthyophis garoensis* Pillai and Ravichandran, 1999 and *I. husaini* Pillai and Ravichandran, 1999, were surveyed. We dug up top soil, sifted through leaf litter, lifted stones, logs, overturned piled up vegetable waste, hay stack, and cow dung in search of caecilians. We collected one specimen atop a hill from a cowherd's compound. The compound had some thirty cattle, young and old. It also had a tree with a 'machhan' to 'watch out' for wild elephants. We searched among the roots and trunks of live/dead plantain. Juveniles were collected from wet surrounding and the rest were picked up from terrestrial habitat. Handpicking is the easier way to collect them.

Though alcohol is advised as a fixative and better preservative since it does not help to retain the natural *Colour* of the material we have used formalin in its place. However in few preserved specimens we observed very fine projections all over the body which looked like 'stubble' These were later confirmed as the exudates of the skin glands (Plate. VIII.D).

ECOLOGY AND NATURAL HISTORY

The first specimen to be picked up was from below soil and leaf litter of the forest floor bordering Rongram river at Rengsangre. More material including metamorphosing individuals were picked up from near a stream. Digging out the black loose soil on hill top (Plate XI A, B) also yielded caecilians and blind snakes of the genus *Ramphotyphlops*. Daribokgre village within the forest cover where caecilians were found along with *Typhlops diardi* was the ideal habitat for collecting them. Collecting these were quite exciting because digging up and lifting stones both resulted in spotting snakes and caecilians and not to forget the ever so alert leeches who 'surveyed' the area diligently day and night! All the caecilians were picked up from under shelter and no material was found moving in the open even at night. Looking for caecilians we also observed/collected snakes namely *Blythia reticulata*, *Xenochrophis piscator* and *Ovophis monticolum*. Caecilians were also found 5 kms inside the Nokrek National Park. Hills under Jhum cultivation was another locale. We collected few specimens from 'jhum' hills where paddy was grown. It is interesting to note

that preparatory to 'jhum' cultivation the vegetation on the hills is cleared and burned ('slash and burn') by the middle of March positively. Thereafter the grains either paddy or maize are sown with the onset of rains (Plate XIII A,B,C). We collected caecilians in June. The juveniles were observed on marshy low land at the base of the hills in September.

Genus *Ichthyophis* Fitzinger, 1826

Medium to large species, with or without a lateral cream or yellow stripe. Four series of teeth; tentacular opening between and below the line of eye and nostrils, usually closer to eye than to nostril; eyes visible externally; primary and secondary folds not separable, folds angular in the mid ventral line; subdermal scales always present; tail short, tapering or blunt. Both head and tail are used in locomotion (II A, B). There is a certain stickiness and odour (like that of the 'dough') to the adult specimen.

Northeast India is reported to have two species of striped *Ichthyophis* namely *I. garoensis* and *I. glutinosus*, the presence of the latter species in the area is doubtful (Frost, 2009) and therefore is not included in the key. Our study material numbering 62 specimens comprises of striped *Ichthyophis*. On closer examination we found this material to belong to four different species including *I. garoensis*. A key is provided here to separate them.

Our study material comprises of striped *Ichthyophis*. To distinguish them from the already known striped species of Northeast India, we provide here a key.

Key to the striped species of *Ichthyophis* of North East India

1. Lateral stripe narrow with uneven border, nuchal region strongly arched *I. nokrekensis* sp. nov.
- Lateral stripe broad, nuchal region flat or slightly arched 2
2. Head flat, depressed 3
- Head not flat, nuchal region slightly arched, lateral stripe broad with even border *I. daribokensis* sp. nov.
3. The ratio of distance between eye to tentacle (0.26-0.60%), eye to snout tip (1.72-1.95%), snout to 1st nuchal groove (3.97-4.52%), tentacle to nostril (0.90-1.20%) and length of disc surrounding vent (0.47-0.96 %) corresponding to its total length is less *I. alfredii* sp. nov.
- The ratio of distance between eye to tentacle (0.64-0.76%), eye to snout tip (1.97-2.45%), snout to 1st nuchal groove (4.81-5.67%), tentacle to nostril (1.53-1.68%) and length of disc surrounding vent (1.06-1.27%) corresponding to its total length is more *I. garoensis*

1. *Ichthyophis alfredii* sp. nov.

(Plate I A, B)

Material examined

Holotype : 1 example, Reg. no. V/A/ERS/ZSI/841, Meghalaya, East Garo Hills, Nokrek Biosphere Reserve, Daribokgre IB compound (Alt. 1119 m, N 25° 29' 34.83" E 90° 19' 26.9"), 24.vi.2008, Coll. R. Mathew and party.

Paratype : 4 examples, Reg. no. V/A/ERS/ZSI/856, Meghalaya, East Garo Hills, Nokrek Biosphere Reserve, Daribokgre IB compound (Alt. 1119 m, N 25° 29' E 34.8° E 90° 19' 26.9"), 24.06.2008, Coll. R. Mathew and party; 1 example, Reg. no. V/A/ERS/ZSI/857, Meghalaya, West Garo Hills, Nokrek Biosphere Reserve, Rongbang, 1.5 km away from Chinapat (Alt. 416 m, N 25° 35' 05" E 90° 17' 12.7"), 23.vi.2008, Coll. R. Mathew and party.

Diagnosis : A fairly large species (Total length 176–330 mm) with 269–299 dorsal annuli and 262–295 ventral annuli; 5–7 annuli broken by vent, 5–7 post vent annuli; 1 dorsal transverse groove on 2nd collar; head long, depressed; tentacular aperture closer to eye than to nostril. Premaxillary-maxillary teeth c. 34–40; Prevomeropalatine teeth c. 32–40; Dentary teeth c. 32–38; Splenial teeth c. 32–40. Scales present on all annuli; lateral stripe distinct, broad, expands on collar and extend on to the lower jaw giving a clear pattern of an 'arrow shape' to gular region; body bulky, supple.

Description of Holotype : A fairly large specimen measuring a total length of 330 mm including 5.75 mm tail. Head flat, (Plate VII C) pointed, longer than broad (distance between snout to 1st nuchal groove 13.10 mm, snout to 3rd nuchal groove 20.63 mm, head width at jaw angle 8.55 mm, head width at occiput 9.52 mm, head depth at 1st nuchal groove 5.14 mm, head depth at 2nd nuchal groove 6.45 mm); eye distinct, white (eye diameter 0.81 mm, distance between eyes 6.48 mm, distance between eye to jaw angle 3.55 mm), placed higher than the level of nostril (distance between eye to margin of upper lip 1.25 mm, nostril to margin of upper lip 1.09 mm); tentacular aperture nearer to eye (1.95 mm) than to nostril (2.98 mm). Distance between tentacles 6.24 mm, tentacle to jaw angle 4.85 mm, tentacle to snout 4.13 mm, tentacle to margin of upper lip 0.17 mm. Distance between nostrils 1.49 mm, between nostril to eye 4.91 mm; nostril to jaw angle 8.35 mm, rostral region concave; distance between eye to snout tip 5.68 mm; snout slightly projecting beyond mouth, (projection of snout beyond anterior margin of upper lip 0.82 mm); distance between snout to jaw angle 8.97 mm. Collars prominent (length of 1st collar 3.33 mm, length of 2nd collar 3.33 mm, distance between jaw angle to 1st nuchal groove 4.08 mm, tip of lower jaw to jaw angle 7.65 mm). 1st nuchal groove distinct laterally and ventrally, dorsally incomplete; 2nd nuchal groove distinct ventrally, faint laterally, dorsally not indicated; 3rd nuchal groove dorsally and laterally distinct, incomplete ventrally. One dorsal transverse groove on 2nd collar. Dorsal annuli wavy, ventral annuli angular anteriorly, less angular posteriorly. A broad lateral stripe (3.54 mm) from head to tail separates dorsal and ventral side. It expands at the collar and extends on to the lower jaw leaving the mental region free, thereby forming an arrow shape at the gular region.

Body folds regular (Plate VIII, D); scales (Plate VIII, E) present on all annuli. Primary and secondary folds 299 dorsally and 292 ventrally (width at mid body 12.90 mm, width at anterior of vent 6.63 mm, circumference at mid body 40 mm), including 6 annuli broken by vent and 6 post vent annuli (length of tail anterior of vent 5.75 mm, posterior of vent 3.93 mm). Tail narrows down to a pointed tip. Disc surrounding vent wider than long (length 1.55 mm, width 1.82 mm). The vent is overhung anteriorly, the aperture exposes part of the genitalia (Plate X, D).

Dentition : Premaxillary-maxillary teeth : c. 38; Prevomero-palatine teeth : c. 36; Dentary teeth : c. 36; Splenial teeth : c. 40.

Colour : Dorsally lavender, paler below. A broad creamish lateral stripe separates the dorsal and ventral side, extending anteriorly to tip of lower jaw except the mental region and partly to the upper jaw; posteriorly the stripe extends beyond vent but not touching the tip of tail. Lateral stripe broadens at the collar imparting an arrow shape pattern at the gular region; a median longitudinal impression present on the gular region.

Variations in Paratypes : Material examined : 5 examples (including 2 juveniles in metamorphosing stage with external ear openings).

Adult individuals (3 exs.) are similar to holotype in external morphology except in meristic data and number of body folds. The total length varies from 282-322 mm. The detailed measurements are given in Table-1.

The specimens measuring 176 and 193 mm are juveniles in transitional stage of development (Plate IX).

We give here a detailed description of the juvenile specimens along with meristic data of the species described (Table-1).

Though the specimens measuring 176 and 193 mm are juveniles having external ear opening, these do not have the spatulate head, ventral position of mouth and nostrils, compressed caudal fin and ridge like dorsolateral and ventral median impression as observed in the juveniles of *I. daribokensis* sp. nov. described herein.

In specimen measuring 176 mm head is flat, eye white, the 2nd nuchal groove is not clear. The ear opening (which is in a closing stage) is spoon shaped with the elongated part extending towards 2nd nuchal groove and is placed on 2nd collar; one dorsal transverse groove on 2nd collar; a median longitudinal impression present on gular region. The “arrow mark” on gular region is prominent. Vent is overhung anteriorly and the aperture exposes genitalia (Plate X, A).

In specimen measuring 193 mm head is flat, eye white, the 2nd nuchal groove is not clear. The ear opening is clear, spoon shaped with the elongated part extending towards 2nd nuchal groove and is placed in 2nd collar. The “arrow mark” on gular region is not prominent. Vent is overhung anteriorly and the aperture exposes genitalia.

We have compared all the newly described species to the known striped species of India namely *I. tricolor*, *I. beddomei*, *I. longicephalus*, *I. garoensis*, *I. glutinosus*, *I. kodaguensis* and also to each other. However, since we could get only nine common characters for *I. tricolor*, *I. beddomei*, *I. garoensis*, *I. longicephalus* and *I. glutinosus*, from literature comparisons to these species could be done only on these characters (Table-2). The measurements and morphological characters of these species taken from literature are expressed here in relation to the total length and are expressed in percentage. Further, on the basis of more material of *I. garoensis* collected during the present study we could compare all the characters studied for the new species with *I. garoensis* (Table-7). Thirty characters of *I. kodaguensis* (Wilkinson *et al.*, 2007) are compared with the new descriptions (Table-8).

Remarks

Ichthyophis alfredii shares similarity with *I. tricolor* only in the presence of a lateral stripe.

It differs from *I. tricolor* in lacking the mid ventral stripe. It also differs in characters like distance between eye to eye, eye to tentacle, eye to nostril, eye to snout, nostril to tentacle, snout to 1st nuchal groove, head width at occiput, width at mid body and length of tail.

Ichthyophis alfredii shares similarities with *I. beddomei* in the characters like distance between eye to eye and nostril to tentacle.

It differs from *I. beddomei* in the characters like distance between eye to tentacle, eye to nostril, eye to snout, snout to 1st nuchal groove, head width at occiput, width at mid body and length of tail.

Ichthyophis alfredii shares similarities with *I. garoensis* in the presence of a lateral stripe, eye diameter, distance between eye to upper lip, nostril to upper lip, tentacle to margin of upper lip, projection of snout beyond anterior margin of upper lip and width of disc surrounding vent.

It differs from *I. garoensis* in the characters like distance between eye to eye, eye to nostril, eye to tentacle, eye to snout, eye to jaw angle, distance between nostrils, nostril to tentacle, nostril to jaw angle, tentacle to jaw angle, tentacle to snout, tentacle to tentacle, snout to jaw angle, snout to 1st nuchal groove, snout to 3rd nuchal groove, jaw angle to 1st nuchal groove, length of 1st and 2nd collar, head depth at 1st and 2nd nuchal groove, head width at jaw angle and occiput, distance between tip of lower jaw to jaw angle, width at anterior of vent, width of lateral stripe, length of tail anterior and posterior of vent, length of disc surrounding vent, width at mid body and circumference at mid body.

Ichthyophis alfredii shares similarity with *I. longicephalus* only in the presence of lateral stripe.

It differs from the latter in the characters like distance between eye to eye, eye to tentacle, eye to nostril, eye to snout, nostril to tentacle, snout to 1st nuchal groove, head width at occiput, width at mid body and length of tail.

Ichthyophis alfredii shares similarities with *I. kodaguensis* in the characters like distance between eye to nostril, eye to jaw angle, nostril to tentacle, tentacle to margin of upper lip, head width at occiput and length of 1st collar.

It differs from the latter in the characters like distance between eye to eye, eye to tentacle, eye to nostril, eye to snout, distance between nostrils, nostril to jaw angle, tentacle to tentacle, tentacle to jaw angle, tentacle to snout, projection of snout beyond upper lip, head depth at 1st nuchal groove, head width at jaw angle, distance between snout to jaw angle, snout to 1st nuchal groove, jaw angle to 1st nuchal groove, tip of lower jaw to jaw angle, length of 2nd collar, width at mid body, circumference at mid body, width at anterior of vent, width of lateral stripe, length of tail anterior and posterior to vent and in the length and width of disc surrounding vent.

Ichthyophis alfredii shares similarities with *I. glutinosus* in the characters like distance between eye to eye, eye to nostril, eye to snout, nostril to tentacle and snout to 1st nuchal groove.

It differs from the latter in the characters like distance between eye to tentacle, head width at occiput, width at mid body and length of tail.

Ichthyophis alfredii sp. nov. shares similarities with *I. daribokensis* sp. nov. in the characters like distance between eye to upper lip, eye diameter, nostril to upper lip, tentacle to jaw angle, tentacle to margin of upper lip and projection of snout beyond anterior margin of upper lip.

It differs from *I. daribokensis* sp. nov. in the characters like distance between eye to eye, eye to snout, eye to nostril, eye to tentacle, eye to jaw angle, distance between nostrils, nostril to jaw angle, nostril to tentacle, tentacle to tentacle, tentacle to snout, snout to 1st and 3rd nuchal groove, snout to jaw angle, jaw angle to 1st nuchal groove, length of 1st and 2nd collar, head depth at 1st and 2nd nuchal groove, tip of lower jaw to jaw angle, head width at jaw angle and occiput, width at anterior of vent, width of lateral stripe, length of tail anterior and posterior to vent, length and width of disc surrounding vent, width at mid body and circumference at mid body.

Ichthyophis alfredii sp. nov. shares similarities with *I. nokrekensis* sp. nov. in the characters like distance between eye to upper lip, eye diameter, nostril to upper lip, tentacle to margin of upper lip and projection of snout beyond anterior margin of upper lip.

It differs from *I. nokrekensis* sp. nov. in the characters like distance between eye to eye, eye to snout, eye to tentacle, eye to nostril, eye to jaw angle, distance between nostrils, nostril to tentacle, nostril to jaw angle, tentacle to snout, tentacle to tentacle, tentacle to jaw angle, jaw angle to 1st nuchal groove, snout to jaw angle, snout to 1st and 3rd nuchal groove, tip of lower jaw to jaw angle, head depth at 1st and 2nd nuchal groove, length of 1st and 2nd

collar, head width at jaw angle and occiput, width at anterior of vent, width of lateral stripe, length of tail anterior and posterior to vent, length and width of disc surrounding vent, width at mid body and circumference at mid body.

Distribution : Garo Hills, Meghalaya.

Habitat : The Type specimens were collected by digging out the forest floor strewn with stones at an altitude of 1119 m above msl. The habitat was shared by *Typhlops diardii*. One paratype was taken from paddy field by the side of Rongram river at an altitude of 416 m at Rongbang (Plate XII, A, B). Two water snakes, *Xenochrophis piscator*, were also collected from here.

On handling this specimen it produced a fairly audible sound like a 'purr' or 'grunt' which could have been due to stress.

Etymology : The species is named in honour of Dr. J.R.B. Alfred, former Director, Zoological Survey of India, Kolkata, who had been an inspiration and guidance behind this study.

Suggested common name : Alfred's striped Caecilian.

2. *Ichthyophis daribokensis* sp. nov.

(Plate II A,B)

Material examined

Holotype : 1 example, Reg. no. V/A/ERS/ZSI/839, Meghalaya, West Garo hills, Nokrek Biosphere Reserve, Rengsangre, Rongram river side (Alt. 522 m, N 25° 34' 21.2" E 90° 17' 57.8"), 19.vi.2008, Coll. R. Mathew and party.

Paratypes : 1 example, Reg. no. V/A/ERS/ZSI/842, Meghalaya, West Garo hills, Nokrek Biosphere Reserve, Rengsangre, Rongram river side (Alt. 437 m, N 25° 34' 21.1" E 90° 17' 57.1"), 28.04.2008, Coll. R. Mathew and party; 3 examples, Reg. no. V/A/ERS/ZSI/843, Meghalaya, East Garo Hills, Nokrek Biosphere Reserve, Sasatgre, (Alt. 341 m, N 25° 28' 09.33" E 90° 15' 23.7"), 26.06.2008, Coll. R. Mathew and party; 1 example, Reg. no. V/A/ERS/ZSI/844, Meghalaya, East Garo Hills, Nokrek Biosphere Reserve, Mondal Nokrat, 25.vi.2008, Coll. R. Mathew and party; 3 examples, Reg. no. V/A/ERS/ZSI/845, Meghalaya, East Garo Hills, Nokrek Biosphere Reserve, Kiwang, 1 km from Daribokgre IB, 25.06.2008, Coll. R. Mathew and party; 1 example, Reg. no. V/A/ERS/ZSI/846, Meghalaya, West Garo Hills, Rengsangre, (Alt. 523 m, N 25° 34.5' 17" E 90° 16' 08.6"), 18.06.2008, Coll. R. Mathew and party; 5 examples (1 adult and 4 juveniles), Reg. no. V/A/ERS/ZSI/847, Meghalaya, East Garo Hills, Nokrek Biosphere Reserve, Daribokgre IB compound, (Alt. 1132 m, N 25° 29' 34.4" E 90° 19' 27.3"), 01.05.2008, Coll. R. Mathew and party.

Diagnosis : A fairly large species (Total length 155-315 mm) with 264-310 dorsal annuli and 263-304 ventral annuli; 4-7 annuli broken by vent, 4-7 post vent annuli; 1-2 dorsal

transverse groove on 2nd collar; head moderately long ; nuchal region moderately arched; tentacular aperture closer to eye than to nostrils. Premaxillary- maxillary teeth c. 34-40; Prevomero-palatine teeth c. 26-36; Dentary teeth c. 36-40; Splenial teeth c. 30-36. Scales present on all annuli; lateral stripe distinct, medium to broad, expand on collar, faintly extending to lower jaw.

Description of Holotype : A fairly large specimen measuring a total length of 315 mm including 7.22 mm tail. Head longer than broad (distance between snout to 1st nuchal groove 13.54 mm, snout to 3rd nuchal groove 19.10 mm, head width at jaw angle 8.59 mm, head width at occiput 9.35 mm); semi arched at nuchal region (head depth at 1st nuchal groove 7.30 mm, head depth at 2nd nuchal groove 7.98 mm); eye moderate (eye diameter 0.98 mm, distance between eyes 6.26 mm, distance between eye to jaw angle 3.94 mm, eye to snout tip 6.45 mm), slightly darker than dorsum, placed lower than nostril (distance between eye to margin of upper lip 0.61 mm, nostril to margin of upper lip 0.69 mm); tentacular aperture nearer to eye (1.36 mm) than to nostril (3.83 mm). Distance between tentacles 6.67 mm, tentacle to jaw angle 4.91 mm, tentacle to snout 4.92 mm. Nostril placed frontally, visible from above, distance between nostrils 1.66 mm, between nostril to eye 5.34 mm; nostril to jaw angle 8.44 mm, rostral region convex; snout slightly projecting beyond mouth (projection of snout beyond anterior margin of upper lip 0.41 mm), distance between snout to jaw angle 9.91 mm. Collars prominent, length of 1st collar 2.76 mm, length of 2nd collar 2.86 mm; distance between jaw angle to 1st nuchal groove 3.02 mm, tip of lower jaw to jaw angle 9.96 mm. 1st nuchal groove faint on dorsum, very distinct laterally and ventrally; 2nd nuchal groove very distinct laterally (upto the lateral stripe) and ventrally, dorsally not indicated; 3rd nuchal groove clear, distinct laterally, dorsally broken and overlapping and ventrally incomplete. Two faint dorsal groove on 2nd collar; dorsal annuli wavy, more so on the anterior region; ventral annuli angular anteriorly. A broad lateral stripe (4.43 mm) from head to tail separates dorsal and ventral side.

Body folds regular; scales present on all annuli. Primary and secondary folds 290 dorsally and 296 ventrally (width at mid body 12.52 mm, width at anterior of vent 5.60 mm, circumference at mid body 43.00 mm), including 5 annuli broken by vent and 7 post vent annuli (length of tail 7.22 mm from anterior end of vent and 5.02 mm from posterior end of vent). Disc surrounding vent round (Plate X, B) (length 2.34 mm, width 2.33 mm). Tail narrows down to a pointed tip.

Dentition : Premaxillary-maxillary teeth : c. 40; Prevomero-palatine teeth : c. 34; Dentary teeth : c. 40; Splenial teeth : c. 36.

Colour : Dorsally glossy dark brown, paler below. A broad, even, yellowish lateral stripe separates the dorsal and ventral side (Plate VII, B), extending anteriorly to expand at the collar and faintly extend to lower jaw (Plate VII, A). Posteriorly lateral stripe encircles the vent and extends slightly further laterally but not reaching the tip of tail.

Variations in Paratypes : Material examined : 14 examples (including 4 juveniles in metamorphosing stage with external ear openings).

Adult individuals (10 examples) are similar to *Holotype* in external morphology except in meristic data and number of body folds. The total length varies from 155-296 mm. The detailed measurements are given in Table.3.

We give here a detailed *Description* of the juvenile specimens along with meristic data of the species described (Table 6).

The four juveniles with varying length of 155 to 177 mm are in the transitional stage of development and possess distinct, round external ear openings and ridge like impression on body dorsolaterally on either side (Plate IX). These show some variation in morphological characters as mentioned below.

In specimen measuring 155 mm, head is spatulate, anterior region vertically truncate; nostrils placed on the truncate region and visible ventrally; lower jaw round; eye white; ear opening on third nuchal groove; 1st nuchal groove distinct ventrally, faint laterally and absent dorsally; 2nd nuchal groove distinct only ventrally; 3rd nuchal groove faint. An impression of a median ventral fold present on the body. Vent a slit only, tail compressed to form a caudal fin.

In specimen measuring 165 mm, head is spatulate, anterior region somewhat truncate; nostrils placed antero-ventrally on the truncate region; ear opening on 2nd nuchal groove; 1st nuchal groove faint dorsally and laterally, ventrally distinct except the median part; 2nd nuchal groove distinct and complete ventrally, laterally and dorsally not very clear; 3rd nuchal groove not distinct ventrally and laterally, slightly distinct dorsally; tentacular opening not clear. Vent a slit, tail compressed to form a fin.

In specimen measuring 171 mm, head is spatulate, anteriorly truncate; eye white, not very distinct; tentacular aperture not prominent, impression only; nostril crescentic, placed ventrally; ear opening on 2nd nuchal groove; 1st nuchal groove broken and overlapping dorsally, ventrally clear but medially absent; 2nd nuchal groove not very distinct laterally but ventrally distinct; 3rd nuchal groove not very distinct dorsally and ventrally, laterally slightly seen. Vent a slit, but thickened (Plate X,C); tail compressed to form a fin; an impression of a median ventral fold.

In specimen measuring 177 mm, head is flat, anteriorly rounded, eye with white rim; tentacular opening distinct; ear opening on 3rd nuchal groove; 1st nuchal groove faint dorsally and laterally, distinct ventrally except the mid region; 2nd nuchal groove distinct, complete ventrally and laterally but dorsally not very clear; 3rd nuchal groove ventrally not distinct, laterally and dorsally slightly distinct. Vent a slit, but thickened; tail slightly compressed without forming a fin.

All the morphometric measurements are given in Table.

Colouration is lighter than in the adult specimens.

Dentition : The teeth which could be seen without damaging the specimens only were counted.

Premaxillary-maxillary teeth	: c. 16-22
Prevomero-palatine teeth	: c. 20-22
Dentary teeth	: c. 16
Splénial teeth	: c. 18

Remarks

Ichthyophis daribokensis sp.nov. shares similarities with *I. tricolor* in the characters like the presence of a lateral stripe, head width at occiput, distance between nostril to tentacle and in the distance between eye to eye.

It differs from *I. tricolor* in lacking the mid ventral stripe. It also differs in the characters like distance between eye to tentacle, eye to nostril, eye to snout, snout to 1st nuchal groove, width at mid body and length of tail.

Ichthyophis daribokensis sp.nov. shares similarities with *I. beddomei* in the characters like distance between eye to nostril, eye to snout and snout to 1st nuchal groove.

It differs from *I. beddomei* in the characters like the distance between eye to eye, eye to tentacle, nostril to tentacle, head width at occiput, width at mid body and length of tail.

Ichthyophis daribokensis sp. nov. shares similarities with *I. garoensis* in the characters like the distance between eye to snout, eye to upper lip, nostril to jaw angle, nostril to upper lip, between nostrils, length of 2nd collar and width of lateral stripe.

It differs from *I. garoensis* in the characters like the distance between eye to nostril, eye to tentacle, eye to jaw angle, nostril to tentacle, tentacle to jaw angle, tentacle to snout, snout to 1st nuchal groove, snout to 3rd nuchal groove, snout to jaw angle, head width at jaw angle, head width at occiput, head depth behind jaw angle, tip of lower jaw to jaw angle, length of 1st and 2nd collar, jaw angle to first nuchal groove, circumference at mid body, length of tail anterior and posterior of vent and width of disc surrounding vent.

Ichthyophis daribokensis sp. nov. shares similarity with *I. longicephalus* only in the presence of a lateral stripe.

It differs from the latter in the characters like the distance between eye to eye, eye to tentacle, eye to nostril, eye to snout, nostril to tentacle, snout to 1st nuchal groove, head width at occiput, width at mid body and length of tail.

Ichthyophis daribokensis sp. nov. shares similarities with *I. kodaguensis* in the characters like the distance between nostrils, tentacle to jaw angle, tentacle to margin of upper lip, tip of lower jaw to jaw angle, length of 2nd collar and length of disc surrounding vent.

It differs from *I. kodaguensis* in the characters like distance between eye to eye, eye to tentacle, eye to nostril, eye to snout, eye to jaw angle, nostril to tentacle, nostril to jaw angle, tentacle to tentacle, tentacle to snout, projection of snout beyond anterior margin of

upper lip, head depth at 1st nuchal groove, head width at angle of jaw and at occiput, snout to jaw angle, snout to 1st nuchal groove, jaw angle to 1st nuchal groove, length of 1st collar, width at mid body, circumference at mid body, width at anterior of vent, width of lateral stripe, length of tail anterior and posterior to vent and width of disc surrounding vent.

Ichthyophis daribokensis sp. nov. shares similarities with *I. glutinosus* in the characters like presence of a lateral stripe and distance between eye to tentacle.

It differs from *I. glutinosus* in the characters like the distance between eye to eye, eye to nostril, eye to snout, nostril to tentacle, snout to 1st and 3rd nuchal groove, head width at occiput, width at mid body and length of tail.

The similarities and differences between *Ichthyophis daribokensis* sp. nov. and *Ichthyophis alfredii* sp. nov. have been dealt with under the *Description of Ichthyophis alfredii* sp. nov.

Ichthyophis daribokensis sp. nov. shares similarities with *I. nokrekensis* sp. nov. in the characters like distance between eye to nostril, eye to eye, eye to tentacle, eye diameter, eye to upper lip, eye to snout, nostril to nostril, nostril to tentacle, nostril to upper lip, tentacle to margin of lip, tentacle to tentacle, tentacle to snout, snout to jaw angle, snout to 1st and 3rd nuchal groove, projection of snout beyond anterior margin of upper lip, jaw angle to 1st nuchal groove, length of 1st and 2nd collar, head depth at 2nd nuchal arch, head width at jaw angle and occiput, width at mid body, width at anterior of vent, length of tail anterior of vent and length of disc surrounding vent.

It differs from *I. nokrekensis* sp. nov. in the characters like distance between eye to jaw angle, tentacle to jaw angle, head depth at 1st nuchal arch, tip of lower jaw to jaw angle, nostril to jaw angle, width of lateral stripe, width of disc surrounding vent, length of tail posterior to vent and circumference at mid body.

Distribution : Garo Hills, Meghalaya.

Habitat : The *Holotype* was dug out from under dry leaves and debris by the side of Rongram river (Plate XII, C). One of the *Paratypes* was collected from hardly a meter above the water level of the Rongram river at Rengsangre. It was picked up from below leaf litter and soil of the forest side of the river. Another specimen was dug out from a hillock in a cow herd's compound. These were also collected from under pile of stones, dug out from earth along with snakes; and picked up from rotten trunk of plantain. The altitude varied from 416 m to 1132 m above msl. The juveniles were collected from the muddy stream side along with two adult specimens.

Etymology : The species name reflects the name of the locality Daribokgre in East Garo hills district of Meghalaya from where the type materials were collected.

Suggested common name : Daribok's striped Caecilian.

3. *Ichthyophis nokrekensis* sp. nov.

(Plate IV A, B, C)

Material examined

Holotype. 1 example, Reg. no. V/A/ERS/ZSI/840, Meghalaya, West Garo Hills, Nokrek Biosphere Reserve, Sasatgre, (Alt. 341 m, N. 25° 28' 09.3" E 90° 15' 39.7"), 26.vi.2008, Coll. R. Mathew and party.

Paratypes. 1 example, Reg. no. V/A/ERS/ZSI/848, Meghalaya, East Garo Hills, Nokrek Biosphere Reserve, Daribokgre, Forest IB compound, (Alt. 1119 m, N. 25° 29' 34.8", E 90° 19' 26.9"), 25.vi.2008, Coll. R. Mathew and party; 1 example, Reg. no. V/A/ERS/ZSI/849, Meghalaya, East Garo Hills, Nokrek Biosphere Reserve, Oragitok, 27.vi.2008, Coll. R. Mathew and party; 1 example, Reg. no. V/A/ERS/ZSI/850, Meghalaya, East Garo Hills, Nokrek Biosphere Reserve, Kiwang, 1 km from Daribokgre IB, 25.vi.2008, Coll. R. Mathew and party; 1 example, Reg. no. V/A/ERS/ZSI/851, Meghalaya, East Garo Hills, Nokrek Biosphere Reserve, Mondal Nokrat, 26.06.2008, Coll. R. Mathew and party; 1 example, Reg. no. V/A/ERS/ZSI/852, Meghalaya, West Garo Hills, Nokrek Biosphere Reserve, Sasatgre, (Alt. 341 m, N. 25° 28' 09.3" E 90° 15' 39.73), 26.vi.2008, Coll. R. Mathew and party; 4 examples, Reg. no. V/A/ERS/ZSI/853, Meghalaya, East Garo Hills, Nokrek Biosphere Reserve, Daribokgre, Forest IB compound, (Alt. 1119 m, N. 25° 29' 34.8", E 90° 19' 26.9"), 25.vi.2008, Coll. R. Mathew and party; 1 example, Reg. no. V/A/ERS/ZSI/854, Meghalaya, East Garo Hills, Nokrek Biosphere Reserve, Daribokgre IB compound (Alt. 1132 m, N. 25° 29' 34.4", E 90° 19' 27.3"), 01.05.2008, Coll. R. Mathew and party; 1 example, Reg. no. V/A/ERS/ZSI/855, Meghalaya, West Garo hills, Rengsangre, Rongram river side, (Alt. 522 m, N. 25° 34' 21.2" E 90° 17' 57.8"); 19.vi.2008, Coll. R. Mathew and party.

Diagnosis : A fairly large species (Total length 206-325 mm) with 269-300 dorsal annuli and 266-302 ventral annuli; 4-6 annuli broken by vent, 5-7 post vent annuli; 1-2 dorsal transverse groove on 2nd collar; head moderately long; nuchal region arched; tentacular aperture closer to eye than to nostril. Premaxillary-maxillary teeth c. 38; Prevomero-palatine teeth c. 36; Dentary teeth c. 40; Splenial teeth c. 34. Scales present on all annuli; a distinct, narrow lateral stripe separates upper and lower surface from collar region to tail.

Description of Holotype : A fairly large specimen measuring a total length of 325 mm including 7.72 mm tail. Head longer than broad (distance between snout to 1st nuchal groove 15.20 mm, snout to 3rd nuchal groove 22.58 mm, head width at jaw angle 9.86 mm, head width at occiput 10.70 mm); arched at nuchal region (Plate VII,C) (Head depth at 1st nuchal groove 9.14 mm, head depth at 2nd nuchal groove 9.52 mm); eye moderate (eye diameter 0.97 mm, distance between eyes 7.25 mm, eye to jaw angle 4.49 mm, eye to snout tip 6.87 mm), prominent, placed higher than nostril (distance between eye to margin of upper lip 1.28 mm, nostril to margin of upper lip 1.05 mm); tentacular aperture nearer to eye (2.59 mm) than to nostril (4.30 mm). Distance between tentacles 6.83 mm, tentacle to jaw angle 6.83 mm, tentacle to snout 4.50 mm, tentacle to margin of upper lip 0.22 mm. Nostril

placed frontally, visible from above, distance between nostrils 2.68 mm, between nostril to eye 6.22 mm; nostril to jaw angle 10.60 mm; rostral region convex; snout slightly projecting beyond mouth (projection of snout beyond anterior margin of upper lip 0.53 mm), distance between snout to jaw angle 12.40 mm. Collars prominent, length of 1st collar 3.16 mm, length of 2nd collar 3.81 mm, distance between jaw angle to 1st nuchal groove 3.29 mm, tip of lower jaw to jaw angle 10.70 mm. The 1st nuchal groove faint on dorsum, prominent laterally and ventrally, broken and overlapping ventrolaterally; 2nd nuchal groove distinct laterally (with impression of three folds on right side, but without any impression on left side) and ventrally, dorsally not visible; 3rd nuchal groove distinct dorsally, laterally and ventrally except median region; one transverse groove dorsally on the 2nd collar; 1st nuchal groove fairly distinct on dorsum, very distinct laterally and ventrally; dorsal annuli wavy, more so on the anterior region; ventral annuli angular anteriorly; a narrow lateral stripe (2.37 mm) from collar to tail separates dorsal and ventral side.

Body folds regular; scales present on all annuli. Primary and secondary folds 292 dorsally and 293 ventrally (width at mid body 14.10 mm, width at anterior of vent 6.36 mm, circumference at mid body 47 mm) including 6 annuli broken by vent and 6 post vent annuli (length of tail anterior of vent 7.72 mm, posterior of vent 4.53 mm). Disc surrounding vent slightly oval, (length 3.11 mm, width 3.00 mm). Tail narrows down to a pointed tip.

Dentition : Premaxillary-maxillary teeth : c. 38; Prevomero-palatine teeth : c. 36; Dentary teeth : c. 40; Splenial teeth : c. 34.

Colour : Dorsally glossy dark brown, paler below. A narrow, uneven, orangish yellowish lateral stripe separates the dorsal and ventral side (Plate VII, B), extending anteriorly to expand at the collar. Posteriorly lateral stripe encircle the vent and extends slightly further laterally but not reaching the tip of tail.

Variations in Paratypes : Material examined : 11 examples. These are similar to holotype in external morphology except in meristic data and number of body folds. The total length varies from 206-318 mm.

The detailed measurements are given in Table-4.

Remarks

Ichthyophis nokrekensis sp. nov. shares similarities with *I. tricolor* in the presence of a lateral stripe and in the character like distance between eye to eye.

It differs from *I. tricolor* in lacking the mid ventral stripe. It also differs in characters like distance between eye to tentacle, eye to nostril, eye to snout, nostril to tentacle, snout to 1st nuchal groove, head width at occiput and width at mid body and length of tail.

Ichthyophis nokrekensis sp. nov. shares similarities with *I. beddomei* in the character like distance between eye to snout and snout to 1st nuchal groove.

It differs from the latter in the characters like distance between eye to eye, eye to tentacle, eye to nostril, nostril to tentacle, head width at occiput, width at mid body and length of tail.

Ichthyophis nokrekensis sp. nov. shares similarities with *I. garoensis* in the characters like distance between eye to eye, eye to nostril, eye to jaw angle, eye to tentacle, eye diameter, distance between nostrils, nostril to upper lip, tentacle to tentacle, tentacle to jaw angle, tentacle to margin of lip, length of 1st and 2nd collar, head width at jaw angle, tip of lower jaw to jaw angle, projection of snout beyond anterior margin of upper lip, length of disc surrounding vent and circumference at mid body.

It differs from *I. garoensis* in the characters like distance between eye to snout, eye to upper lip, nostril to tentacle, nostril to jaw angle, tentacle to snout, snout to jaw angle, snout to 1st and 3rd nuchal groove, jaw angle to 1st nuchal groove, width of disc surrounding vent, head depth at 1st and 2nd nuchal groove, head width at occiput, width at anterior of vent, width of lateral stripe, length of tail anterior and posterior of vent and width at mid body.

Ichthyophis nokrekensis sp. nov. shares similarity with *I. longicephalus* only in the presence of lateral stripe.

It differs from the latter in the characters like distance between eye to eye, eye to tentacle, eye to nostril, eye to snout, nostril to tentacle, snout to 1st nuchal groove, head width at occiput, width at mid body and length of tail.

Ichthyophis nokrekensis sp. nov. shares similarities with *I. kodaguensis* in the characters like distance between eye to tentacle, eye to snout, tentacle to jaw angle, tentacle to margin of upper lip, length and width of disc surrounding vent.

It differs from *I. kodaguensis* in the characters like distance between eye to eye, eye to nostril, eye to jaw angle, distance between nostrils, nostril to tentacle, nostril to jaw angle, tentacle to tentacle, tentacle to snout, projection of snout beyond anterior margin of upper lip, head depth at 1st nuchal groove, snout to jaw angle, snout to 1st nuchal groove, jaw angle to 1st nuchal groove, tip of lower jaw to jaw angle, length of 1st and 2nd collar, head width at jaw angle and occiput, width and circumference at mid body, width at anterior of vent, width of lateral stripe and length of tail anterior and posterior to vent.

Ichthyophis nokrekensis sp. nov. shares similarity with *I. glutinosus* only in the character like distance between eye to tentacle.

It differs from *I. glutinosus* in the characters like distance between eye to eye, eye to nostril, eye to snout, nostril to tentacle, snout to 1st nuchal groove, head width at occiput, length of tail, snout to 3rd nuchal groove and width at mid body.

The similarities and differences between *Ichthyophis nokrekensis* sp. nov. and *Ichthyophis alfredii* sp. nov. have been dealt with under *Ichthyophis alfredii* sp. nov.

The similarities and differences between *Ichthyophis nokrekensis* sp. nov. and *Ichthyophis daribokensis* sp. nov. have been dealt with under the *Description of Ichthyophis daribokensis* sp. nov.

Distribution : Garo Hills, Meghalaya.

Habitat : One specimen was dug out from under dry leaves and debris by the side of river-Rongram (Plate XI, D). They were also collected from under pile of stones (Plate XI, C), dug out from earth along with snakes. The altitude varied from 416 m to 1132 m above msl. The juveniles were collected from the muddy stream side along with two adult specimens. The study area falls under the Reserve Forest and is comparatively undisturbed.

Etymology : The species name reflects the name of the Biosphere Reserve from where the type materials were collected.

Suggested common name : Nokrek's striped Caecilian.

4. *Ichthyophis garoensis* Pillai and Ravichandran, 1999

(Plate III A, B)

1999. *Ichthyophis garoensis*, Pillai and Ravichandran, *Rec. zool. Surv. India, Occ. Paper No.*, 172 : 30-34.

Material examined : 1 example, Reg. no. V/A/ERS/ZSI/858, Meghalaya, West Garo Hills, Nokrek Biosphere Reserve, Rongbang, 1.5 km away of Chinapat (Alt. 416 m, N 25° 32' 29.4" E 90° 23' 26"), 23.vi.2008, Coll. R. Mathew and party; 2 examples, Reg. no. V/A/ERS/ZSI/859, Meghalaya, East Garo hills, Nokrek Biosphere Reserve, Didari, (Alt. 1088 m, N 25° 29' 08.6" E 90° 19' 02.7"), 25.vi.2008, Coll. R. Mathew and party.

Pillai and Ravichandran, 1999, described *I. garoensis* from Anogiri lake, Garo hills, Meghalaya based on two specimens measuring 225 and 310 mm. There had been no further report or additional information on this species. We collected three examples measuring 160-216 mm. A detailed description of the same is given below :

This is a comparatively smaller species measuring a total length of 160-216 mm including 4.48-6.05 mm tail. Head flat, longer than broad (distance between snout to 1st nuchal groove 8.17-10.39 mm, head width at occiput 5.93-6.48 mm, head width at jaw angle 4.86-5.99 mm; Head depth at 1st nuchal groove 3.59-3.89 mm, head depth at 2nd nuchal groove 3.92-4.56 mm); eye white, moderate (eye diameter 0.55-0.93 mm, distance between eyes 3.53-3.95 mm), prominent, placed higher than nostril (distance between eye to margin of upper lip 0.55-0.65 mm, nostril to margin of upper lip 0.40-0.58 mm); tentacular aperture nearer to eye (1.21-1.38 mm) than to nostril (2.44-3.62 mm). Nostril placed frontally, visible from above, distance between nostrils 0.88-1.62 mm, between nostril to eye 2.93-3.79 mm; rostral region convex; distance between eye to snout tip 3.92-4.32 mm; snout slightly projecting beyond mouth, (projection of snout beyond anterior margin of upper lip 0.22-0.40 mm). Collars prominent, length of 1st collar 1.76-2.89 mm, length of 2nd collar 1.70-2.55 mm; distance between snout to 3rd nuchal groove 11.51-14.40 mm. 1st nuchal groove distinct laterally, ventrally and either faintly or clearly distinct

dorsally; 2nd nuchal groove distinct laterally and either clearly or just indicated dorsally and ventrally; 3rd nuchal groove distinct laterally and dorsally, not clear ventrally; annuli wavy dorsally, ventrally angular (Table 5).

Primary and secondary folds 282-287 dorsally and 276-286 ventrally including 4-5 annuli broken by vent and 6-7 post vent annuli. Tail with pointed tip. Disc surrounding vent oval to round (length of disc surrounding vent 1.70-2.35 mm, width 1.14-1.71 mm). Body folds regular; scales present on all annuli.

Dentition : Premaxillary-maxillary teeth : c. 38; Prevomeropalatine teeth : c. 36, Dentary teeth : c. 32; Splenial teeth : c. 30.

Colour : Dorsally lavender, paler below. A broad lateral stripe (width of lateral stripe 1.96-2.43 mm) separates the dorsal and ventral side, extending anteriorly to expand at the collar and form an 'arrow' shape pattern on the gular region (Plate VII, A). Posteriorly lateral stripe encircles the vent and extends slightly further laterally but not reaching the tip of tail.

DISCUSSION

Caecilians were collected from Nokrek Biosphere Reserve in East and West Garo Hills districts of Meghalaya between April to September, 2008. A total of 62 specimens including 25 juveniles were collected. Detailed study revealed four species including three species new to science. These three species namely *Ichthyophis alfredii* sp. nov., *Ichthyophis daribokensis* sp. nov. and *Ichthyophis nokrekensis* sp. nov. are described here in detail. Juveniles belonging to *I. alfredii* sp. nov., and *I. daribokensis* sp. nov. (Plates V and VI) are also described. For each species, materials examined, diagnostic characters, *Description of Holotype* and *Paratypes* including measurements, distribution, habitat, similarities and dissimilarities with other species are given. All the measurements are given in tables. The new species have been compared with the literature of the known striped species of India. Photographs of types and habitat have been incorporated. While describing the specimens we have not stressed on dental count as we did not find much variation in this character (Plate VIII, A, B, C).

As this manuscript was being finalized another field survey to the study area was conducted during the last week of September, 2008 and nineteen juveniles and seven adult specimens of *Ichthyophis* were collected. Of these, twelve juveniles ranging from 116 to 165 mm were collected from Anogre, the type locality of *I. garoensis*, and belong to *I. garoensis* Pillai and Ravichandran, 1999. The remaining seven juveniles ranging from 64 to 130 mm were picked up from (Plate XIII, D) Wadogre and belong to *I. daribokensis* sp. nov. These specimens are in the transitional stage of development. We have described these along with meristic data and have incorporated pictures of these juveniles in the text showing the position of mouth, opercular openings, ridge or groove like feature on body and caudal fin. The six adult specimens belong to *I. garoensis*, *I. daribokensis* sp. nov., and *I. nokrekensis* sp. nov. The juveniles were taken from under stones and pebbles in the wet

marshy land adjacent to a small stream draining into and bordering the paddy fields below. The adult specimens were dug up from land either from the river bank below bamboo plant, or from the jhum land or from under stones by the forest or dug out from within the Reserve Forest in the Nokrek National Park. All these were picked up from within two to six inches depth. We also collected caecilians from sheath of plantain trunk.

The occurrence of the juveniles in various stages of development in the month of September suggests that these may be available in the similar natural conditions through October, thereafter on completion of 'growth and development' and in the drop in temperature during the winter months these may take shelter deep beneath soil. On searching one may find them near the vicinity of water.

SUMMARY

A total of 62 specimens including 25 juveniles were collected and studied. Three new species namely *Ichthyophis alfredii* sp. nov., *Ichthyophis daribokensis* sp. nov., and *Ichthyophis nokrekensis* sp. nov., are described. Juveniles of *I. alfredii* sp. nov., *I. daribokensis* sp. nov., and *I. garoensis* Pillai and Ravichandran, 1999 are described. Various juvenile characters are highlighted. Information on *Ichthyophis garoensis* Pillai and Ravichandran, 1999, is updated.

ACKNOWLEDGEMENTS

The authors are grateful to Dr. Ramakrishna, Director, Zoological Survey of India, Kolkata for permission to undertake the study and to the Officer-in-Charge, Eastern Regional Station, Zoological Survey of India, Shillong for laboratory facilities. We would like to thank Dr. David Gower of The Natural History Museum, London for valuable suggestions and information on the group. We are indebted to Meghalaya State Forest Department, in particular to Shri. V.K. Nautiyal, IFS, Principal Chief Conservator of Forests for permission to survey the project area. We thank Shri. P.R. Marak MFS, Conservator of Forests and Shri. A.N. Sangma, DFO, Wild life division, Tura for providing facilities and assistance during field surveys. Thanks are also to Shri K.K. Deb, Field Collector, Shri. S. Swell, Collection tender, Shri. Nirmal Sapkota, Laboratory attendant and Shri. K.M. Surendran, Driver for field assistance during the surveys.

REFERENCES

- Gower, D.J., Alex Kupfer, Oommen V. Oommen, Werner Himstedt, Ronald A. Nussbaum, Simon P. Loader, Bronwen Presswell, Hendrik Muller, Sharath B. Krishna, Renaud Boistel and Mark Wilkinson, 2002. A molecular Phylogeny of Ichthyophiid Caecilians (Amphibia : Gymnophiona : Ichthyophiidae) : Out of India or out of South East Asia? *Proc. R. Soc. Lond. (B)*. Vol. **269**, No. 1500 : 1563-1569.
- Kupfer, Alexander., Armin Kramer and Werner Himstedt 2004. Sex-related growth patterns in a caecilian amphibian (genus *Ichthyophis*) : evidence from laboratory data. *Journal of Zoology*, **262** : 173-178.
- Pillai, R.S. and Ravichandran, M.S. 1999. Gymnophiona (Amphibia) of India-A taxonomic study. *Rec. zool. Surv. India, Occ. Paper No.*, **172** : 1-126 (Published by the Director, *Zool. Surv. India, Kolkata*).
- Taylor, E.H. 1960a. A new caecilian genus in India. *Univ. Kansas Sci. Bull.*, **40** : 31-36.
- Taylor, E.H. 1960b. On the caecilian species *Ichthyophis monochrous* and *Ichthyophis glutinosus* with *Description of related species*. *Univ. Kansas Sci. Bull.*, **40** : 37-120.
- Taylor, E.H. 1961. Notes on Indian caecilians. *J. Bombay nat. Hist. Soc.*, **58** : 355-365.
- Taylor, E.H. 1964. A new species of caecilian from India (Amphibia: Gymnophiona). *Senck. Biol. Bd.*, **45**, Heft 3/5 : 227-231.
- Taylor, E. H. 1968. *The Caecilians of the World : A Taxonomic Review*. *Kansas University Press, Lawrence*, : 1-846.
- Wilkinson, M., D.J. Gower, V. Govindappa and G. Venkatachalaiah, 2007. A new species of *Ichthyophis* (Amphibia : Gymnophiona : Ichthyophiidae) from Karnataka, India. *Herpetologica*, **63**(4) : 511-518.

Table-1. Different Morphological Counts and Measurements of *Ichthyophis alfredii* sp. nov.
(Measurements expressed in Millimeter).

	HOLOTYPE	PARATYPES					Mean	Range
	1	2	3	4	5	6		
1. Total Length (mm)	330	322	282	193 juvenile	176 juvenile	305	268	(176-330)
Counts								
2. Ventral annuli	292	278	295	274	260	279	280	(260-295)
3. Dorsal annuli	299	283	293	278	269	287	285	(269-299)
4. Annuli broken by vent	6	6	6-7	5	5	5	5	(5-7)
5. Post-vent annuli	6	6	5	6	7	7	6	(5-7)
6. Dorsal transverse groove on 2nd collar	1	0	0	0	0	1	1	(1)
Measurements (mm)								
7. Eye diameter	0.81	1.05	1.06	0.87	0.85	1.19	0.97	(0.81-1.19)
8. Distance between Eye-upper lip	1.25	1.24	1.08	0.62	0.62	1.19	1.00	(0.62-1.25)
9. Distance between eyes	6.48	5.97	5.25	3.93	3.93	5.65	5.20	(3.93- 6.48)
10. Distance between Eye-tentacle	1.95	1.21	1.66	0.79	0.45	1.82	1.31	(0.45-1.95)
11. Distance between Eye-nostril	4.91	5.19	4.32	3.39	2.83	4.53	4.20	(2.83- 5.19)
12. Distance between Eye-snout tip	5.68	5.95	5.50	3.51	3.19	5.79	4.94	(3.19- 5.95)
13. Distance between Eye-jaw angle	3.55	4.49	3.03	1.99	1.27	4.15	3.08	(1.27- 4.49)
14. Distance between nostrils	1.49	1.84	1.08	0.78	0.54	1.95	1.28	(0.54-1.95)
15. Distance between Nostril-tentacle	2.98	3.51	3.37	1.89	1.79	3.54	2.85	(1.79-3.54)
16. Distance between Nostril-jaw angle	8.35	7.41	8.08	5.46	5.10	9.49	7.32	(5.10-9.49)
17. Distance between Nostril-upper lip	1.09	0.86	0.89	0.46	0.58	1.19	0.85	(0.46-1.19)

	HOLOTYPE	PARATYPES					Mean	Range
	1	2	3	4	5	6		
18. Distance between Tentacles	6.24	6.00	5.69	3.56	3.55	6.57	5.27	(3.55-6.57)
19. Distance between Tentacle-jaw angle	4.85	4.73	4.87	3.51	3.20	5.75	4.49	(3.20-5.75)
20. Distance between Tentacle-Snout tip	4.13	4.56	4.07	2.76	2.84	4.87	3.87	(2.76-4.87)
21. Distance between Tentacle-margin of lip	0.17	0.17	0.00	0.58	0.10	0.14	0.23	(0.10-0.58)
22. Projection of snout beyond anterior margin of upper lip	0.82	0.85	0.79	0.51	0.41	0.61	0.67	(0.41-0.85)
23. Head depth at 1st nuchal groove	5.14	4.91	5.87	3.34	3.13	6.40	4.80	(3.13-6.40)
24. Head depth at 2nd nuchal groove	6.45	6.47	6.66	3.23	3.96	7.63	5.73	(3.23-7.63)
25. Head width at jaw angle	8.55	8.72	7.52	4.61	4.67	9.22	7.22	(4.61-9.22)
26. Head width at occiput	9.52	9.37	8.48	5.40	5.62	9.81	8.04	(5.42-9.81)
27. Distance between Snout-jaw angle	8.97	9.15	8.48	5.88	6.15	10.12	8.13	(5.88-10.12)
28. Distance between Snout-1st nuchal groove	13.10	12.91	12.00	0.00	7.95	13.34	11.86	(7.95-13.34)
29. Distance between Snout- 3rd nuchal groove	20.63	19.51	18.61	14.66	13.23	19.18	17.64	(13.23-20.63)
30. Distance between Jaw angle-1st nuchal groove	4.08	4.88	3.58	0.00	2.74	3.37	3.73	(2.74- 4.88)
31. Distance between tip of lower jaw- jaw angle	7.65	7.85	7.41	6.26	5.13	9.36	7.28	(5.13- 9.36)
32. Length of 1st collar (lateral)	3.33	4.28	3.57	0.00	0.00	3.63	3.7	(3.33- 4.28)
33. Length of 2nd collar (lateral)	3.33	2.75	3.10	0.00	0.00	2.55	2.93	(2.55-3.33)

	HOLOTYPE	PARATYPES					Mean	Range
	1	2	3	4	5	6		
34. Width at mid body	12.90	13.51	11.50	7.35	6.52	13.76	10.92	(6.52-13.76)
35. Circumference at mid	40.00	45.00	44.00	30.00	28.00	48.00	39.17	(28.0-48.0)
36. Width at anterior of vent	6.63	6.96	5.33	3.59	3.70	6.57	5.46	(3.59-6.96)
37. Width of lateral stripe (at mid body)	3.54	3.65	2.31	1.51	2.13	4.74	2.98	(1.51-4.74)
38. Length of tail from anterior end of vent	5.75	7.62	5.99	4.97	4.73	7.01	6.01	(4.73-7.62)
39. Length of tail from posterior end of vent	3.93	4.50	2.70	3.35	3.23	4.08	3.63	(2.70-4.50)
40. Length of disc surrounding vent	1.55	3.00	2.70	1.82	1.37	2.75	2.20	(1.37-3.00)
41. Width of disc surrounding vent	1.82	3.23	1.92	1.62	1.15	2.75	2.08	(1.15-3.23)

Note : For juvenile specimens where characters are not distinct, measurements have been given as 0.00

Table 2. Comparison of different morphological characters (mean value) of three new species with other related striped species of *Ichthyophis* from India (in percentage with relation to total length)

	Characters	<i>I. tricolor</i>	<i>I. beddomei</i>	<i>I. longicephalus</i>	<i>I. kodaguensis</i>	<i>I. glutinosus</i>	<i>I. garoensis</i>	<i>I. nokrekensis</i> sp. nov.	<i>I. alfredii</i> sp. nov.	<i>I. daribokensis</i> sp. nov.
1	Distance between eyes	2.21	1.99	2.75	2.07	1.96	2.08	2.17	1.97	2.19
2	Distance between eye to tentacle	0.88	0.88	0.94	0.72	0.64	0.76	0.65	0.47	0.63
3	Distance between eye to nostril	2.03	1.72	2.30	1.66	1.62	1.91	1.84	1.58	1.79
4	Distance between eye to snout tip	2.37	2.11	2.83	2.07	1.85	2.22	2.15	1.84	2.18
5	Distance between nostril to tentacle	1.21	1.00	1.71	1.04	1.11	1.54	1.34	1.06	1.29
6	Head width at occiput	3.37	3.14	3.84	3.07	3.20	3.25	3.47	3.00	3.42
7	Distance between snout-1st nuchal groove	5.11	4.48	5.79	4.44	4.23	5.08	4.56	4.23	4.55
8	Width at mid body	4.93	4.92	4.81	3.49	4.59	4.16	4.40	4.04	4.48
9	Length of tail	1.35	1.36	1.84	1.41	1.83	2.39	2.64	2.30	2.70

Table-3. Different morphological counts and measurements of *Ichthyophis daribokensis* sp. nov.
(Measurements expressed in millimeter)

	Holotype					Paratypes							
	1	2	3	4	5	6	7	8	9	10	11	Mean	(Range)
1. Total Length (mm)	315	283	255	262	258	252	234	275	285	155	296	261	(155-315)
Counts													
2. Ventral annuli	296	278	304	264	275	283	276	277	272	270	263	278	(263-304)
3. Dorsal annuli	290	282	310	264	275	280	279	278	273	271	264	279	(264-310)
4. Annuli broken by vent	5	6	6	5	6	5	5	4	7	5	5		(4-7)
5. Post-vent annuli	7	6	6-7	4	5	5	7	6	5	6	4		(4-7)
6. Dorsal transverse groove on 2nd collar	2	2	1	1	0	1	1	2	0	2	1		(1-2)
Measurements (mm)													
7. Eye diameter	0.98	0.93	1.09	0.72	0.74	0.93	1.10	1.03	1.26	0.75	1.01	0.96	(0.72-1.26)
8. Distance between Eye-upper lip	0.61	1.05	1.29	0.90	1.05	1.24	1.33	1.29	1.26	0.54	1.08	1.06	(0.54-1.33)
9. Distance between eye	6.26	5.65	5.42	5.73	5.03	5.88	5.47	5.77	6.35	3.78	6.99	5.67	(3.78-6.99)
10. Distance between Eye-tentacle	1.36	1.29	1.59	1.58	1.72	1.94	1.72	1.77	1.86	0.98	2.24	1.64	(0.98-2.24)
11. Distance between Eye-nostril	5.34	5.18	4.21	4.48	4.39	4.78	4.65	4.74	4.88	2.92	5.64	4.66	(2.92-5.64)
12. Distance between Eye-snout tip	6.45	6.00	5.37	5.60	6.23	5.29	5.23	5.92	5.83	3.72	6.53	5.65	(3.72-6.53)
13. Distance between Eye-jaw angle	3.94	3.65	2.90	3.89	3.05	2.88	2.46	2.63	3.45	1.96	4.08	3.17	(1.96-4.08)
14. Distance between nostrils	1.66	2.25	1.55	2.33	2.16	1.86	1.71	2.24	2.41	1.37	2.13	1.97	(1.37-2.41)

	Holotype	Paratypes												
	1	2	3	4	5	6	7	8	9	10	11	Mean	(Range)	
15. Distance between Nostril-tentacle	3.83	3.44	2.90	3.51	3.94	3.11	2.90	3.34	3.59	1.99	4.63	3.38	(1.99-4.63)	
16. Distance between Nostril-jaw angle	8.44	9.22	7.23	8.12	8.41	7.39	7.06	8.26	9.09	5.54	9.94	8.06	(5.54-9.94)	
17. Distance between Nostril-upper lip	0.69	0.66	0.74	0.90	0.99	0.79	0.80	0.90	0.89	0.54	0.75	0.79	(0.54-0.99)	
18. Distance between Tentacles	6.67	5.94	5.43	5.37	6.02	5.86	5.44	5.77	6.80	3.93	7.18	5.86	(3.93-7.18)	
19. Distance between Tentacle-jaw angle	4.91	5.41	3.92	4.84	4.32	4.26	4.18	5.07	5.05	3.50	5.03	4.59	(3.50-5.41)	
20. Distance between Tentacle-Snout tip	4.92	4.56	3.96	4.57	4.57	4.26	4.18	4.56	4.79	3.19	5.03	4.42	(3.19-5.03)	
21. Distance between Tentacle-margin of lip	0.00	0.00	0.12	0.25	0.20	0.00	0.00	0.00	0.00	0.00	0.17	0.19	(0.12-0.25)	
22. Projection of snout beyond anterior margin of upper lip	0.41	0.48	0.48	0.63	0.93	1.04	0.67	1.13	1.06	0.52	0.71	0.73	(0.41-1.13)	
23. Head depth at 1st nuchal groove	7.30	6.72	6.37	7.04	6.77	7.34	5.47	6.77	7.23	4.41	6.80	6.57	(4.41-7.34)	
24. Head depth at 2nd nuchal groove	7.98	7.84	8.19	8.32	7.30	7.99	6.69	8.45	8.28	4.72	7.82	7.60	(4.72-8.32)	
25. Head width at jaw angle	8.59	8.29	8.87	8.95	8.00	7.83	6.98	7.05	8.54	5.64	8.51	7.93	(5.64-8.95)	
26. Head width at occiput	9.35	8.64	9.39	9.28	9.29	9.39	7.82	8.77	9.71	5.87	9.91	8.86	(5.87-9.91)	
27. Distance between Snout-jaw angle	9.91	10.01	9.53	9.20	9.39	8.35	8.36	8.71	10.02	6.13	10.19	9.07	(6.13-10.19)	
28. Distance between Snout 1st nuchal groove	13.54	12.26	11.20	11.50	11.75	11.22	11.10	12.32	12.50	8.08	14.12	11.67	(8.08-14.12)	

	Holotype	Paratypes											
	1	2	3	4	5	6	7	8	9	10	11	Mean	(Range)
29. Distance between Snout - 3rd nuchal groove	19.10	18.50	17.53	16.48	16.80	16.70	15.99	17.17	18.00	12.22	20.49	17.18	(12.22-20.49)
30. Distance between jaw angle-1st nuchal groove	3.02	2.40	2.23	2.31	2.52	2.06	2.43	3.34	2.29	1.72	3.42	2.52	(1.72-3.42)
31. Distance between tip of low jaw- jaw angle	9.96	9.46	8.35	8.32	8.86	7.29	7.59	7.70	8.59	5.58	8.72	8.22	(5.58-9.96)
32. Length of 1st collar (lateral)	2.76	2.93	2.35	2.66	2.40	2.40	2.10	1.79	3.24	2.19	2.67	2.50	(1.79-3.24)
33. Length of 2nd collar (lateral)	2.86	2.85	2.67	2.77	3.14	3.42	3.20	3.22	2.80	2.04	3.48	2.95	(2.04-3.48)
34. Width at mid body	12.52	10.94	11.90	12.30	11.22	11.86	11.21	14.59	12.31	7.13	11.95	11.63	(7.13-14.59)
35. Circumference at mid body	43.00	40.00	42.00	44.00	34.00	48.00	43.00	52.00	45.00	25.00	42.00	41.64	(25-52)
36. Width at anterior of vent	5.60	5.66	6.87	5.78	5.45	5.29	5.76	6.13	6.30	4.01	5.75	5.69	(4.01-6.87)
37. Width of lateral stripe (at mid body)	4.43	3.24	3.06	2.93	3.23	3.06	2.82	5.21	3.33	1.77	3.31	3.31	(1.77-4.43)
38. Length of tail from anterior end of vent	7.22	6.97	6.50	7.92	7.03	7.08	6.93	7.08	9.02	4.38	6.86	7.00	(4.38-9.02)
39. Length of tail from posterior end of vent	5.02	4.37	4.23	4.40	4.40	5.25	4.00	3.98	5.43	3.12	3.74	4.36	(3.12-5.43)
40. Length of disc surrounding vent	2.34	2.79	2.71	3.56	3.00	2.29	2.67	2.41	3.42	1.57	3.28	2.73	(1.57-3.56)
41. Width of disc surrounding vent	2.33	1.95	2.24	2.30	2.37	2.29	2.48	2.45	2.72	1.39	2.10	2.24	(1.39-2.48)

Table-4. Different morphological counts and measurements of *Ichthyophis nokrekensis* sp. nov. (measurements expressed in millimeter)

	Holotype					Paratypes								
	1	2	3	4	5	6	7	8	9	10	11	12	Mean (Range)	
1. Total Length (mm)	325	305	270	290	245	318	306	210	246	226	206	271	268	(206-325)
counts														
2. Ventral annuli	293	266	284	292	270	295	302	284	289	271	289	286	285	(266-302)
3. Dorsal annuli	292	270	285	294	276	300	298	291	283	269	286	288	286	(269-300)
4. Annuli broken by vent	6	5	5	5	4	6	5	6	5	5	6	6	5	(4-6)
5. Post-vent annuli	6	6	7	6	6	5	7	5	5	5	6	6	6	(5-7)
6. Dorsal transverse groove on 2nd collar	1	2	2	2	2	2	2	2	1	1	2	1	1-2	(1-2)
Measurements (mm)														
7. Eye diameter	0.97	1.06	0.74	1.04	1.10	0.87	1.36	1.17	1.05	0.81	1.15	0.98	1.03	(0.74-1.36)
8. Distance between Eye-upper lip	1.28	1.38	1.26	1.25	1.04	1.76	1.36	0.87	1.12	0.73	1.17	0.98	1.18	(0.73-1.76)
9. Distance between eyes	7.25	6.20	5.93	5.79	5.63	6.65	6.28	5.21	4.88	5.36	5.01	5.21	5.78	(4.88-7.25)
10. Distance between Eye-tentacle	2.59	1.82	1.99	2.27	1.43	2.20	2.17	1.08	1.18	1.53	1.72	1.22	1.77	(1.08-2.59)
11. Distance between Eye-nostril	6.22	5.12	4.96	4.92	4.83	5.77	5.43	3.55	4.23	4.12	4.53	5.21	4.91	(3.55-6.22)
12. Distance between Eye-snout tip	6.87	6.26	6.15	5.42	5.79	6.68	6.24	4.74	5.45	4.37	5.25	5.33	5.71	(4.37-6.87)
13. Distance between Eye-jaw angle	4.49	3.75	3.30	3.39	2.87	5.69	3.80	3.17	2.92	3.09	2.74	3.68	3.57	(2.74-5.69)
14. Distance between nostrils	2.68	2.21	1.95	2.00	2.05	1.26	2.52	1.36	1.95	1.99	2.12	1.96	2.00	(1.26-2.68)
15. Distance between Nostril-tentacle	4.30	3.80	3.27	3.46	3.58	4.05	3.99	3.36	3.44	2.71	3.25	3.50	3.56	(2.71-4.30)

Holotype	Paratypes													
	1	2	3	4	5	6	7	8	9	10	11	12	Mean (Range)	
16. Distance between Nostril-jaw angle	10.60	8.89	8.67	8.87	7.82	11.60	9.73	7.60	7.74	7.57	7.23	8.73	8.75	(7.23-11.6)
17. Distance between Nostril-upper lip	1.05	1.11	0.91	0.79	0.98	0.82	0.88	0.54	0.64	0.73	1.06	0.61	0.84	(0.54-1.11)
18. Distance between Tentacles	6.83	6.62	5.86	5.79	6.15	6.56	6.96	4.82	5.74	4.75	5.36	5.55	5.92	(4.75-6.96)
19. Distance between Tentacle-jaw angle	6.83	4.94	5.11	5.14	4.07	7.93	5.58	4.51	4.69	4.37	3.87	4.71	5.15	(3.87-7.93)
20. Distance between Tentacle-Snout tip	4.50	4.94	4.73	4.44	4.47	5.07	4.88	3.87	4.34	3.78	3.87	4.45	4.45	(3.78-5.07)
21. Distance between Tentacle-margin of lip	0.22	0.18	0.03	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.16	(0.03-0.22)
22. Projection of snout beyond anterior margin of upper lip	0.53	0.58	0.39	0.95	0.72	0.54	0.80	0.68	0.72	0.59	0.55	0.46	0.63	(0.39-0.95)
23. Head depth at 1st nuchal groove	9.14	7.58	6.78	7.31	7.69	7.10	8.42	5.62	5.71	5.88	7.11	6.67	7.08	(5.62-9.14)
24. Head depth at 2nd nuchal groove	9.52	9.22	7.71	8.30	8.33	8.66	8.89	6.17	7.04	7.41	6.67	7.63	7.96	(6.17-9.52)
25. Head width at jaw angle	9.86	9.30	8.32	8.12	8.16	9.53	8.98	6.51	6.84	6.71	7.60	7.38	8.11	(6.51-9.86)
26. Head width at occiput	10.70	10.22	9.50	9.00	9.45	11.73	9.45	7.62	8.61	8.21	8.20	8.25	9.25	(7.62-11.73)
27. Distance between Snout-jaw angle	12.40	9.54	9.83	9.43	8.96	11.98	10.63	8.17	8.81	7.90	7.77	8.87	9.52	(7.77-12.4)
28. Distance between Snout-1st nuchal groove	15.20	12.94	12.55	12.22	12.10	15.07	12.93	9.82	11.46	9.99	10.26	11.69	12.19	(9.82-15.07)

Holotype	Paratypes													
	1	2	3	4	5	6	7	8	9	10	11	12	Mean (Range)	
29. Distance between Snout- 3rd nuchal groove	22.58	18.24	18.87	17.21	18.19	20.89	19.09	14.16	16.19	14.54	14.54	16.45	17.58	(14.16-22.58)
30. Distance between Jaw angle-1st nuchal groove	3.29	2.40	2.21	2.30	3.70	2.65	2.14	1.49	2.16	1.82	1.50	3.03	2.39	(1.49-3.70)
31. Distance between tip of low jaw- jaw angle	10.70	8.54	9.32	8.94	8.17	12.01	9.91	8.14	7.46	7.48	7.12	8.92	8.89	(7.12-12.01)
32. Length of 1st collar (lateral)	3.16	2.72	2.98	2.41	2.30	2.94	3.12	2.24	2.56	2.31	2.63	2.08	2.62	(2.08-3.16)
33. Length of 2nd collar (lateral)	3.81	3.24	3.47	3.40	3.28	3.13	2.82	2.05	3.04	2.65	2.80	2.78	3.04	(2.05-3.81)
34. Width at mid body	14.10	13.13	11.76	12.22	12.42	13.67	13.01	8.95	10.68	8.81	10.62	11.52	11.74	(8.81-14.10)
35. Circumference at mid body	47.00	50.00	45.00	45.00	41.00	47.00	48.00	35.00	36.00	31.00	40.00	40.00	42.08	(31.0-50.0)
36. Width at anterior of vent	6.36	6.67	5.34	6.34	4.89	5.71	6.70	4.73	5.85	4.84	5.76	4.89	5.67	(4.73-6.7)
37. Width of lateral stripe (at mid body)	2.37	2.87	2.60	1.60	2.46	2.62	2.36	2.10	1.73	1.57	1.96	2.23	2.21	(1.57- 2.87)
38. Length of tail from anterior end of vent	7.72	9.20	7.12	7.30	5.87	7.15	7.38	5.87	6.82	6.27	6.47	7.06	7.02	(5.87- 9.2)
39. Length of tail from posterior end of vent	4.53	5.39	4.27	4.32	3.62	3.58	4.70	3.58	3.67	3.87	3.87	4.47	4.16	(3.58- 5.39)
40. Length of disc surrounding vent	3.11	3.72	2.85	3.17	2.76	3.70	2.54	1.71	2.74	2.37	2.58	2.76	2.83	(1.71- 3.72)
41. Width of disc surrounding vent	3.00	3.08	2.40	2.78	2.51	3.02	2.41	2.08	2.74	1.91	2.58	2.40	2.58	(1.91- 3.08)

Table-5. Different morphological counts and measurements of *Ichthyophis garoensis* (measurements expressed in millimeter).

	1	2	3	Mean	(Range)
1. Total Length (mm)	160	216	180	185	(160-216)
Counts					
2. Ventral annuli	286	285	276	282	(276-286)
3. Dorsal annuli	287	287	282	285	(282-287)
4. Annuli broken by vent	4	5	5	4-5	
5. Post-vent annuli	6	7	7	6-7	
6. Dorsal transverse groove on 2nd collar	0	0	0	0	
Measurements (mm)					
7. Eye diameter	0.61	0.93	0.55	0.70	(0.55-0.93)
8. Distance between Eye-upper lip	0.61	0.65	0.55	0.60	(0.55-0.65)
9. Distance between eyes	3.88	3.53	3.95	3.79	(3.53-3.95)
10. Distance between Eye-tentacle	1.21	1.38	1.31	1.30	(1.21-1.38)
11. Distance between Eye-nostril	2.93	3.73	3.79	3.48	(2.93-3.79)
12. Distance between Eye-snout tip	3.92	4.26	4.32	4.17	(3.92-4.32)
13. Distance between Eye-jaw angle	1.91	2.90	2.64	2.48	(1.91-2.90)
14. Distance between nostrils	0.88	1.62	1.48	1.33	(0.88-1.62)
15. Distance between Nostril-tentacle	2.44	3.62	2.96	3.01	(2.44-3.62)
16. Distance between Nostril-jaw angle	4.88	6.16	6.25	5.76	(4.88-6.25)
17. Distance between Nostril-upper lip	0.54	0.58	0.40	0.51	(0.40-0.58)
18. Distance between Tentacles	3.62	4.49	4.19	4.10	(3.62-4.49)
19. Distance between Tentacle-jaw angle	3.08	3.79	3.73	3.53	(3.08-3.79)
20. Distance between Tentacle-Snout tip	2.98	3.79	3.40	3.39	(2.98-3.79)
21. Distance between Tentacle-margin of lip	0.07	0.00	0.24	0.16	(0.07-0.24)
22. Projection of snout beyond anterior margin of upper lip	0.40	0.22	0.26	0.29	(0.22-0.40)
23. Head depth at 1st nuchal groove	3.89	3.59	3.82	3.77	(3.59-3.89)
24. Head depth at 2nd nuchal groove	4.56	3.92	4.31	4.26	(3.92-4.56)
25. Head width at jaw angle	4.86	5.99	5.68	5.51	(4.86-5.99)
26. Head width at occiput	5.93	6.48	6.12	6.18	(5.93-6.48)

		1	2	3	Mean	(Range)
27.	Distance between Snout-jaw angle	5.53	7.70	7.13	6.79	(5.53-7.70)
28.	Distance between Snout-1st nuchal groove	8.17	10.39	10.20	9.59	(8.17-10.39)
29.	Distance between Snout- 3rd nuchal groove	11.51	14.40	12.67	12.86	(11.51-14.40)
30.	Distance between Jaw angle-1st nuchal groove	2.51	3.30	3.35	3.05	(2.51-3.35)
31.	Distance between tip of low jaw-jaw angle	5.05	7.14	6.81	6.33	(5.05-7.14)
32.	Length of 1st collar (lateral)	1.76	2.42	2.89	1.76	(1.76-2.89)
33.	Length of 2nd collar (lateral)	1.74	1.93	2.55	1.74	(1.70-2.55)
34.	Width at mid body	7.35	7.58	7.90	7.61	(7.35-7.90)
35.	Circumference at mid body	28.00	30.00	29.00	29.00	(28.00-30.00)
36.	Width at anterior of vent	4.19	3.83	4.41	4.14	(3.83-4.41)
37.	Width of lateral stripe (at mid body)	2.38	1.96	2.43	2.26	(1.96-2.43)
38.	Length of tail from anterior end of vent	4.48	5.89	6.05	5.47	(4.48-6.05)
39.	Length of tail from posterior end of vent	2.77	3.95	3.98	3.57	(2.77-3.95)
40.	Length of disc surrounding vent	1.70	2.35	2.28	2.11	(1.70-2.35)
41.	Width of disc surrounding vent	1.71	1.38	1.14	1.41	(1.14-1.71)

Table-6. Different morphological counts and measurements of juveniles of *Ichthyophis daribokensis* sp. nov. (measurements expressed in millimeter and percentage to total length)

		in mm	in %	in mm	in %	in mm	in %	in mm	in %
1.	Total length	171		165		177		155	
2.	Ventral annuli	284		276		294		276	-
3.	Dorsal annuli	285		266		297		276	
4.	Annuli broken by vent	6		6		5		6	-
5.	Post-vent annuli	6		4		6		6	
6.	Dorsal transverse groove on 2nd collar	0		0		0	-	0	
7.	Eye-eye	4.51	2.64	4.19	2.54	4.38	2.47	3.24	2.09
8.	Eye-tentacle	0.52	0.30	0.80	0.48	0.96	0.54	0.79	0.51
9.	Eye-nostril	3.18	1.86	3.14	1.90	3.33	1.88	2.50	1.61
10.	Eye-snout	3.88	2.27	3.76	2.28	3.83	2.16	3.55	2.29
11.	Eye-jaw angle	2.16	1.26	1.90	1.15	1.68	0.95	1.82	1.17
12.	Distance between nostrils	2.48	1.45	2.52	1.53	1.39	0.79	1.96	1.26
13.	Nostril-tentacle	2.71	1.58	2.18	1.32	2.50	1.41	1.96	1.26
14.	Nostril-jaw angle	5.04	2.95	4.80	2.91	5.07	2.86	4.32	2.79
15.	Tentacle-Tentacle	4.55	2.66	4.19	2.54	4.20	2.37	3.70	2.39
16.	Tentacle-jaw angle	2.79	1.63	1.99	1.21	2.80	1.58	2.98	1.92
17.	Tentacle-Snout	3.52	2.84	3.46	2.10	2.84	1.60	2.77	1.79
18.	Tentacle-margin of lip	1.45	0.85	1.56	0.95	0.77	0.44	1.00	0.65
19.	Projection of snout beyond anterior margin of upper lip	1.26	0.74	1.13	0.68	0.96	0.54	0.98	0.63
20.	Head depth at 1st nuchal arch	5.28	3.09	5.57	3.38	4.97	2.81	4.24	2.74
21.	Head depth at 2nd nuchal arch	5.31	3.11	5.59	3.39	4.87	2.75	4.34	2.80
22.	Head width at jaw angle	6.19	3.62	6.07	3.68	6.19	3.50	5.45	3.52
23.	Head width at occiput	7.20	4.21	6.23	3.78	6.75	3.81	5.91	3.81
24.	Snout-jaw angle	5.60	3.27	5.43	3.29	5.35	3.02	5.37	3.46
25.	Snout-1st groove	9.03	5.28	7.82	4.74	8.88	5.02	7.63	4.92
26.	Jaw angle-1st groove	3.16	1.85	1.65	1.00	2.79	1.58	2.83	1.83
27.	tip of low jaw- jaw angle	4.50	2.63	4.08	2.47	5.10	2.88	4.13	2.66
28.	Length of 1st collar (lateral)	2.47	1.44	1.68	1.02	2.34	1.32	1.76	1.14

		in mm	in %	in mm	in %	in mm	in %	in mm	in %
29.	Length of 2nd collar (lateral)	2.07	0.41	1.27	0.77	2.39	1.35	1.76	1.14
30.	Width at mid body	7.33	4.29	7.73	4.68	7.96	4.50	6.75	4.35
31.	Circumference at mid body	28.00	16.37	30.00	18.18	30.00	16.95	26.00	16.77
32.	Width at anterior of vent	4.18	2.44	3.95	2.39	5.21	2.94	3.40	2.19
33.	Width of lateral stripe (mid body)	2.42	1.71	2.80	1.70	1.71	0.97	2.03	1.31
34.	Length of tail anterior end of vent	5.63	3.29	6.38	3.87	5.92	3.34	6.03	3.89
35.	Length of tail posterior end of vent	3.69	2.16	4.37	2.65	3.69	2.08	4.18	2.70
36.	Length of disc surrounding vent	2.20	1.29	2.04	1.24	1.72	0.97	1.92	1.24
37.	Width of disc surrounding vent	1.87	1.09	1.31	0.79	1.57	0.89	1.27	0.82
38.	Eye diameter	0.89	0.52	0.75	0.45	0.74	0.42	1.04	0.67
39.	Eye-upp lip	1.60	0.94	1.42	0.86	0.74	0.42	1.04	0.67
40.	Nostril-upp lip	0.65	0.38	0.73	0.44	0.61	0.34	0.92	0.59
41.	Snout- 3rd nuchal groove	12.70	7.43	11.01	6.67	13.06	7.38	10.90	7.03

Table-7. Mean value of different morphological counts and measurements of *I. alfredii* sp. nov., *I. daribokensis* sp. nov., *I. nokrekensis* sp. nov. and *I. garoensis* (measurements expressed in percentage to total length)

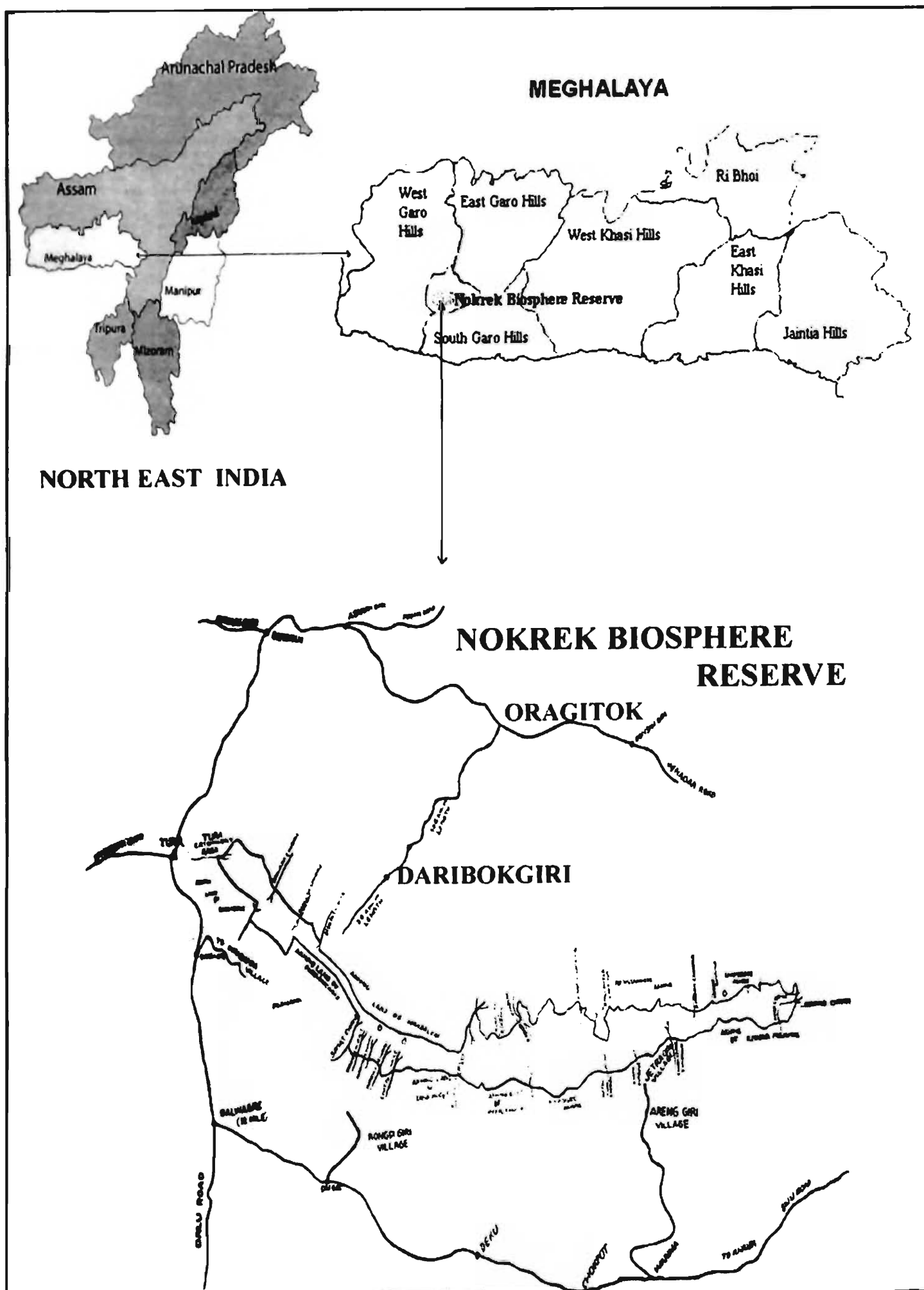
		Mean <i>I. alfredii</i>	Mean <i>I. daribokensis</i>	Mean <i>I. nokrekensis</i>	Mean <i>I. garoensis</i>
1.	Total Length (mm)	268	261	268	185
2.	Ventral annuli	280	278	285	282
3.	Dorsal annuli	285	279	286	285
4.	Annuli broken by vent	5-7	5	5	5
5.	Post-vent annuli	5-7	6	5	7
6.	Dorsal transverse groove on 2nd collar	1	1 - 2	2	0
7.	Eye diameter	0.38	0.37	0.39	0.37
8.	Distance between Eye-upper lip	0.37	0.41	0.44	0.33
9.	Distance between eyes	1.97	2.19	2.17	2.08
10.	Distance between Eye-tentacle	0.47	0.63	0.65	0.71
11.	Distance between Eye-nostril	1.58	1.79	1.84	1.89
12.	Distance between Eye-snout tip	1.84	2.18	2.15	2.27
13.	Distance between Eye-jaw angle	1.11	1.21	1.33	1.33
14.	Distance between nostrils	0.46	0.76	0.76	0.71
15.	Distance between Nostril-tentacle	1.06	1.29	1.34	1.62
16.	Distance between Nostril-jaw angle	2.76	3.11	3.27	3.12
17.	Distance between Nostril-upper lip	0.31	0.30	0.32	0.28
18.	Distance between Tentacles	1.96	2.26	2.22	2.22
19.	Distance between Tentacle-jaw angle	1.70	1.78	1.91	1.92
20.	Distance between Tentacle-Snout tip	1.46	1.71	1.67	1.83
21.	Distance between Tentacle-margin of lip	0.1	0.07	0.05	0.06
22.	Projection of snout beyond anterior margin of upper lip	0.25	0.29	0.24	0.16
23.	Head depth at 1st nuchal groove	1.80	2.54	2.66	2.07
24.	Head depth at 2nd nuchal groove	2.12	2.93	2.97	2.35
25.	Head width at jaw angle	2.67	3.08	3.04	2.99
26.	Head width at occiput	3.00	3.42	3.47	3.37
27.	Distance between Snout-jaw angle	3.07	3.50	3.56	3.66

		Mean <i>I. alfredii</i>	Mean <i>I. daribokensis</i>	Mean <i>I. nokrekensis</i>	Mean <i>I. garoensis</i>
28.	Distance between Snout-1st nuchal groove	4.23	4.55	4.56	5.20
29.	Distance between Snout- 3rd nuchal groove	6.81	6.64	6.58	6.96
30.	Distance between Jaw angle-1st nuchal groove	1.34	0.97	0.89	1.65
31.	Distance between tip of low jaw-jaw angle	2.77	3.17	3.33	3.42
32.	Length of 1st collar (lateral)	1.2	0.98	0.99	1.10
33.	Length of 2nd collar (lateral)	0.95	1.15	1.14	1.09
34.	Width at mid body	4.04	4.48	4.40	4.16
35.	Circumference at mid body	14.82	16.06	15.78	15.83
36.	Width at anterior of vent	2.03	2.21	2.14	2.28
37.	Width of lateral stripe (at mid body)	1.09	1.26	0.83	1.25
38.	Length of tail from anterior end of vent	2.30	2.70	2.64	2.96
39.	Length of tail from posterior end of vent	1.41	1.69	1.57	1.92
40.	Length of disc surrounding vent	0.83	1.05	1.06	1.14
41.	Width of disc surrounding vent	0.77	0.87	0.97	0.78

Table-8. Mean value of different morphological measurements of *I. alfredii* sp. nov., *I. daribokensis* sp. nov., *I. nokrekensis* sp. nov. and *I. kodaguensis* (measurements expressed in percentage to total length)

		<i>I. alfredii</i> sp. nov.	<i>I. daribokensis</i> sp. nov.	<i>I. nokrekensis</i> sp. nov.	<i>I. kodaguensis</i>
1.	Eye-eye	1.97	2.19	2.17	2.07
2.	Eye-tentacle	0.47	0.63	0.65	0.72
3.	Eye-nostril	1.58	1.79	1.84	1.66
4.	Eye-snout	1.84	2.18	2.15	2.07
5.	Eye-jaw angle	1.11	1.21	1.33	1.12
6.	Dist betw nostril	0.46	0.76	0.76	0.83
7.	Nostril-tentacle	1.06	1.29	1.34	1.04
8.	Nostril-jaw angle	2.76	3.11	3.27	2.9
9.	Tentacle-Tenta	1.96	2.26	2.22	2.08
10.	Tentacle-jaw angle	1.70	1.78	1.91	1.86
11.	Tentacle-Snout	1.46	1.71	1.67	1.55
12.	Tentacle-margin of lip	0.1	0.07	0.05	0.12
13.	Projection of snout beyond anterior margin of upper lip	0.25	0.29	0.24	0.36
14.	Head depth at 1st nuchal arch	1.80	2.54	2.66	1.96
15.	Head width at jaw angle	2.67	3.08	3.04	2.88
16.	Head width at occiput	3.00	3.42	3.47	3.07
17.	Snout-jaw angle	3.07	3.50	3.56	3.28
18.	Snout-1st groove	4.23	4.55	4.56	4.44
19.	Jaw angle-1st groove	1.34	0.97	0.89	1.23
20.	tip of low jaw- jaw angle	2.77	3.17	3.33	3.1
21.	Length of 1st collar (lateral)	1.2	0.98	0.99	1.19
22.	Length of 2nd collar (lateral)	0.95	1.15	1.14	1.24
23.	Width at mid body	4.04	4.48	4.40	3.49
24.	Circumference at mid body	14.82	16.06	15.78	13.65

		<i>I. alfredii</i> sp. nov.	<i>I. daribokensis</i> sp. nov.	<i>I. nokrekensis</i> sp. nov.	<i>I. kodaguensis</i>
25.	Width at anterior of vent	2.03	2.21	2.14	1.54
26.	Width of lateral stripe (mid body)	1.09	1.26	0.83	0.69
27.	Length of tail anterior end of vent	2.30	2.70	2.64	1.41
28.	Length of tail posterior end of vent	1.41	1.69	1.57	0.8
29.	Length of disc surrounding vent	0.83	1.05	1.06	0.98
30.	Width of disc surrounding vent	0.77	0.87	0.97	0.91



Map showing collection localities



PLATE - I : A. Dorsal and B. Ventral view of *Ichthyophis alfredii* sp. nov.



PLATE - II : A. Dorsal and B. Ventral view of *Ichthyophis daribokensis* sp. nov.



PLATE - III : A. Dorsal and B. Ventral view of *Ichthyophis garoensis*



PLATE - IV : A and B. Dorsal and C. Ventral view of *Ichthyophis nokrekensis* sp. nov.



PLATE - V : Juveniles of *Ichthyophis alfredii* sp. nov. B and C. *Ichthyophis daribokensis* sp. nov.



PLATE - VI : A, B, C, Juveniles of *Ichthyophis garoensis*



PLATE - VII : A. Gular region with and without 'arrow' pattern B. Lateral stripe in *Ichthyophis nokrekensis* sp. nov. *Ichthyophis daribokensis* sp. nov. C. 'Arched and flat' head in *Ichthyophis nokrekensis* sp. nov. and *Ichthyophis alfredii* sp. nov.

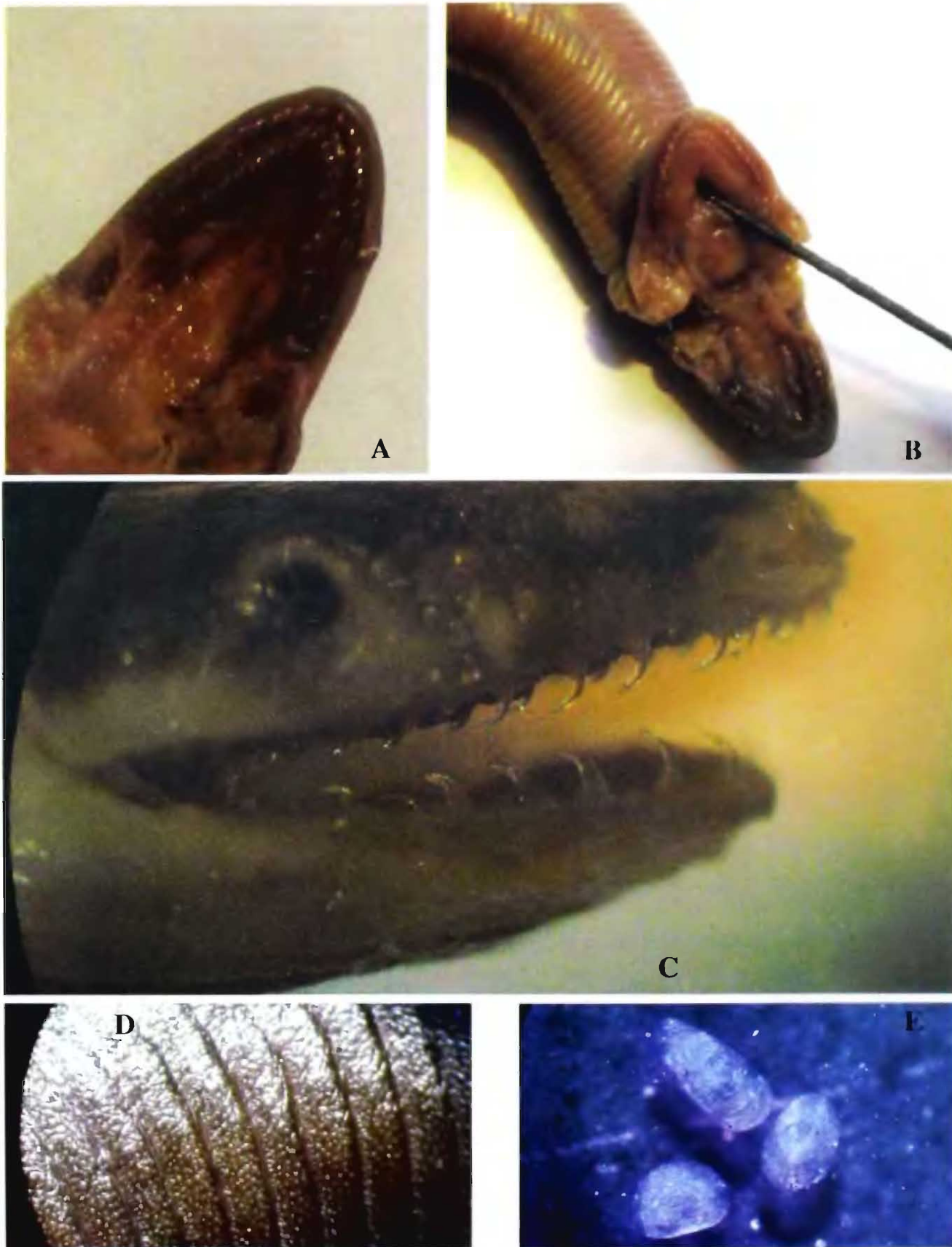


PLATE - VIII : A.B.C - Dentition, D, Skin and E - Scales under magnification in *Ichthyophis* species

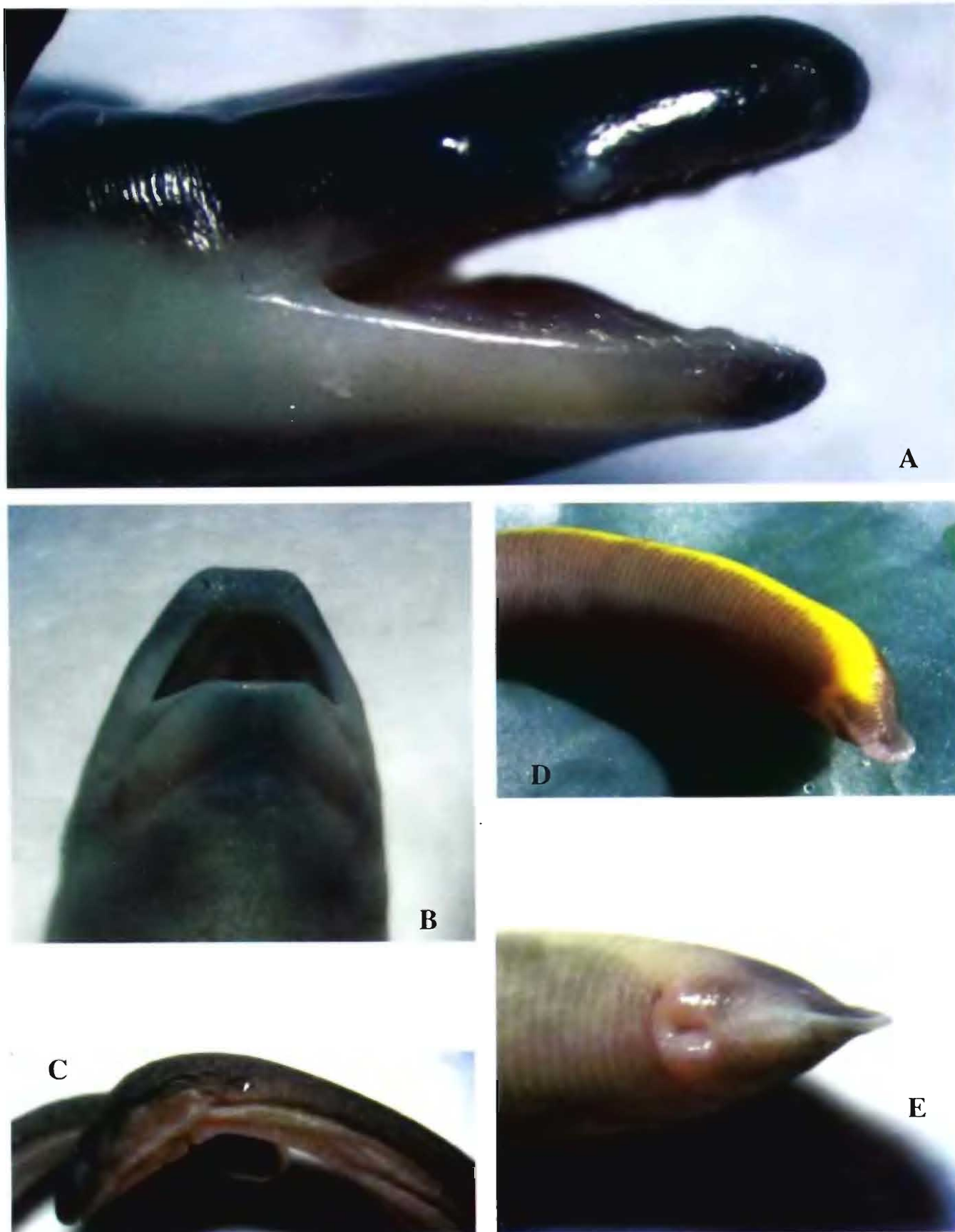


PLATE IX : Showing juvenile features A. Juvenile head, B. Position of mouth and nostril, C. Opercular opening, D, Caudal fin and E. 'vent and tail' in juvenile.

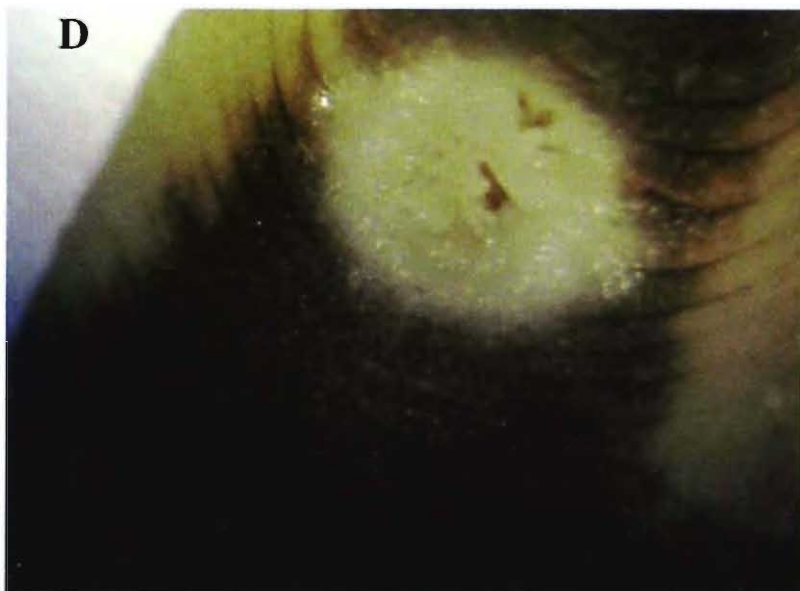


PLATE - X : Showing the 'vent and tail' in *Ichthyophis* spp.



PLATE - XI : Collection spots - A. Wadrore



PLATE - XI : Collection spots - B. Wadrore



PLATE - XI : Collection spots - C. Daribokgre



PLATE - XI : Collection spots - D. Rongram river, Rengsangre



PLATE - XII : Collection spots - **A.** Rongbang



PLATE - XII : Collection spots - **B.** Rongbang



PLATE - XII : Collection spots - C. Rengsangre



PLATE - XII : Collection spots - D. Daribokgre



PLATE - XIII : Collection spots - A. Jhum cultivation 'Slash and burn'



PLATE - XIII : Collection spots - B. 'Slash and burn'



PLATE - XIII : Collection spots - C. Weeding in progress



PLATE - XIII : D. Picking up juvenile of *Ichthyophis daribokensis* sp. nov. at Wadrogre