A REASSESSMENT OF THE PHYLOGENETIC POSITION OF THE FAMILY COBITIDAE (OSTARIOPHYSI)

(ILLUSTRATIONS)

ALICE MARGARET PARSHALL

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c. Noemacheilus strauchi
d. Ellopostoma
e. Vaillantella
f. Misgurnus anguillicaudatus
g. Lepidocephalus thermalis
h. Acanthopsis choirorhynchus
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b. cobitines
c. botines.

Abbreviations used in figures

A1	=	A1 division of adductor mandibulae
A1D	=	Dorsal division of A1
A1DD	=	Additional dorsal division of A1
A1DDD	=	Deep dorsal division of A1
A1L	=	Lateral division of A1 in Psilorhynchus
A1LAC	=	Division of A1 inserting on lachrymal
A1LE	=	Division of A1 inserting on lateral ethmoid
A1M	=	Medial division of A1
A1V	=	Ventral division of A1 in Psilorhynchus
A2	=	A2 division of adductor mandibulae
A3	=	A3 division of adductor mandibulae
Aω	=	Aω division of adductor mandibulae
AA	=	Anguloarticular
AC	=	Aortic canal
ADLOP	=	Anterodorsolateral process of operculum
AHH	=	Anterior hypohyal
ANT	=	Antorbital
ANTLATAP	=	Anterolateral aperture in swimbladder capsule
AOFA	=	Additional occipital facet
APT	=	Archipterygium of pelvis
APTF	=	Aperture between archipterygia of pelvis
ASR	=	Anterior saccular recess
B	=	Botini (On systematic figures)
BB	=	Basibranchial (numbered)
BM	=	Maxillary barbel
BMM	=	Maxillomandibulary (rictal) barbel
BO	=	Basioccipital

BORET	=	Reticulated extension of basioccipital
BP	=	Pharyngeal process of basioccipital
BR	=	Rostral barbel
C	=	Cobitini (on systematic figures)
CB	=	Ceratobranchial (numbered)
CH	=	Ceratohyal
CL	=	Cleithrum
CLA	=	Claustrum
CLL	=	Lateral lamina of cleithrum
CLM	=	Medial process of cleithrum
CLO	=	Oblique lamina of cleithrum
CM	=	Coronomeckelian
CORCLF	=	Coracocleithral (anterior) foramen
CORO	=	Oblique lamina of coracoid
CORV	=	Vertical lamina of coracoid
CP	=	Coronoid process of dentary
DEN	=	Dentary
E	=	<u>Ellopostoma</u> (on Systematic figures)
EB	=	Epibranchial (numbered)
EC	=	Epicranial
ECT	=	Ectopterygoid
EH	=	Epihyal
ENT	=	Entopterygoid
EPO	=	Epioccipital
ES	=	Extrascapula
ET	=	Ethmoid
EU	=	Epural

EXO = Exoccipital

F1X = Foramen for ninth cranial nerve

FX = Foramen for tenth cranial nerve

FX1 = Foramen for eleventh cranial nerve

FIC = Foramen for internal carotid artery

FM = Foramen magnum

FON = Posterior cranial fontanelle

FPCA = Frontoparietal sensory canal

FR = Frontal

FRNLE = Notch on frontal for lateral ethmoid

FRNME = Notch on frontal for mesethmoid

G = Gastromyzonini (on systematic figures)

GL = Glenoid cavity

H = Homalopterini (on systematic figures)

HB = Hyobranchial (numbered)

HE = Hemiethmoid

HM = Hyomandibula

HMF = Articular fossa for hyomandibula

HU = Hypural (numbered)

HM TRUNK = Hyomandibular nerve trunk

HM TRUNK MX = Maxillary division of hyomandibular nerve trunk

ICL = Intercalarium

IFB = Infrapharyngobranchial (numbered)

IH = Interhyal

IM = Intermandibularis

INC = Intercalarium

INM = Intermuscular ossification

INT	=	INT division of A1
IO	=	Infraorbital ossification
IOCA	=	Infraorbital canal
IOL	=	Interossicular ligament
IOP	=	Interoperculum
ISE	=	Ischial element of pelvic radial series
ISP	=	Ischial process of pelvis
KE	=	Kinethmoid
LAC	=	Lachrymal
LATAP	=	Lateral aperture in swimbladder capsule
LE	=	Lateral ethmoid
LEANP	=	Anterior process of lateral ethmoid
LEAP	=	Ascending process of lateral ethmoid
LEARP	=	Articular process of lateral ethmoid
LELACP	=	Lachrymal process of lateral ethmoid
LELL	=	Lateral ethmoid limiting ligament
LELSP	=	Lateral spine process of lateral ethmoid
LESP	=	Main spine process of lateral ethmoid
LL	=	Lateral line
LOF	=	Lateral occipital foramen
LPM	=	Palatomaxillary ligament
MC	=	Meckels cartilage
MCOR	=	Mesocoracoid
ME	=	Mesethmoid
MPT	=	Metapterygoid
MR	=	m. rostralis (mr in text)
MR'	=	Additional belly of m. rostralis (mr' in text)

MR''	=	Second additional belly of m. rostralis (mr^{2t} in text)
MRMX	=	Division of m. rostralis inserting on maxilla (m.r.max.in text)
MX	=	Maxilla
MXAP	=	Anterior process of maxilla
MXA1P	=	Process of maxilla for insertion of A1
MXPEP	=	Process of maxilla articulating with preethmoid
MXRP	=	Rostral process of maxilla
N	=	Noemacheilini [on systematic figures]
NA	=	Neural arch [numbered]
NC	=	Neural complex
NS	=	Neural spine [numbered]
OBS	=	Orbitosphenoid
OBSALE	=	Orbitosphenoid articular surface for lateral ethmoid
OBSP	=	Orbitosphenoid platform
OCCA	=	Occipital canal
OP	=	Operculum
OS	=	Os suspensorium
OSP	=	Oesophageal process of P4
P1	=	Lateral process of V1
P2	=	Lateral process of V2
P2D	=	Descending portion of divided P2
P2H	=	Horizontal portion of divided P2
P4	=	Lateral process of V4
P4D	=	Descending portion of divided P4
P4H	=	Horizontal portion of divided P4
PAL	=	Palatine
PALPP	=	Posterior process of palatine
PAR	=	Parietal

PARPPT = Posterior process of parietal towards posttemporal

PCL = Postcleithrum

PE = Preethmoid (numbered 1 and 2 when 2 are present)

PHB = Inferior pharyngeal bone

PHBLP = Lateral process of inferior pharyngeal bone

PHH = Posterior hypohyal

PHU = Parhypural

PHUA = Parhypurapophysis

PMX = Premaxilla

PMXAP = Ascending process of premaxilla

POP = Preoperculum

PP = Parapophysis

PPAL = Prepalatine

PRO = Prootic

PS = Parasphenoid

PSAP = Ascending process of parasphenoid

PSFANT = Anterior foramen of parasphenoid

PT = Postemporal

PTO = Pterotic

PTOPP = Posterior process of pterotic

PTS = Pterosphenoid

PU = Preural centrum (numbered)

PV = Prevomer

QU = Quadrate

QUPP = Posterior process of quadrate

RA = Retroarticular

RAD = Radial element

RPE	=	Rostral process of ethmoid
RWA	=	Anterior fan-shaped rostral wall in *Ellopostoma*
SC	=	Scaphium
SCAP	=	Scapula
SCL	=	Supracleithrum
SE	=	Supraethmoid
SES	=	Sesamoid
SL	=	Sublingual
SMX	=	Submaxillary
SN	=	Supraneural (numbered)
SO	=	Supraoccipital
SOP	=	Suboperculum
SOR	=	Supraorbital
SPO	=	Sphenotic
SPOP	=	Suprapreoperculum
ST	=	Supratemporal
STF	=	Subtemporal fossa
SUSF	=	Suspensorium fenestra
SYM	=	Symplectic
TO	=	Temporal opening
TGFA	=	Anterior trigeminofacial foramen
TGFP	=	Posterior trigeminofacial foramen
TRI	=	Tripus
TRITP	=	Transformator process of tripus
UN	=	Uroneural
US	=	Urostylè
V	=	Vaillantellini (on systematic figures)
VNUMBERED	=	Vertebra (numbered)

VCOR = Vertical lamina of coracoid

VOM = Vomer

VOMPP = Posterior process of vomer

 = Chondrified structures

 = PTS on figs Liii and Liv

THE APPROXIMATE SCALE OF THE DRAWINGS IS SHOWN ON THE INDIVIDUAL FIGURES.

 = Apomorphy on systematic figures

Fig. i External oral features (Ventral view)

a. *Noemacheilus yarkandensis*

b. *Noemacheilus nigromaculatus*

c. *Noemacheilus rupecola*

d. *Noemacheilus botia*

e. *Misgurnus*

f. *Lepidocephalus annandali*

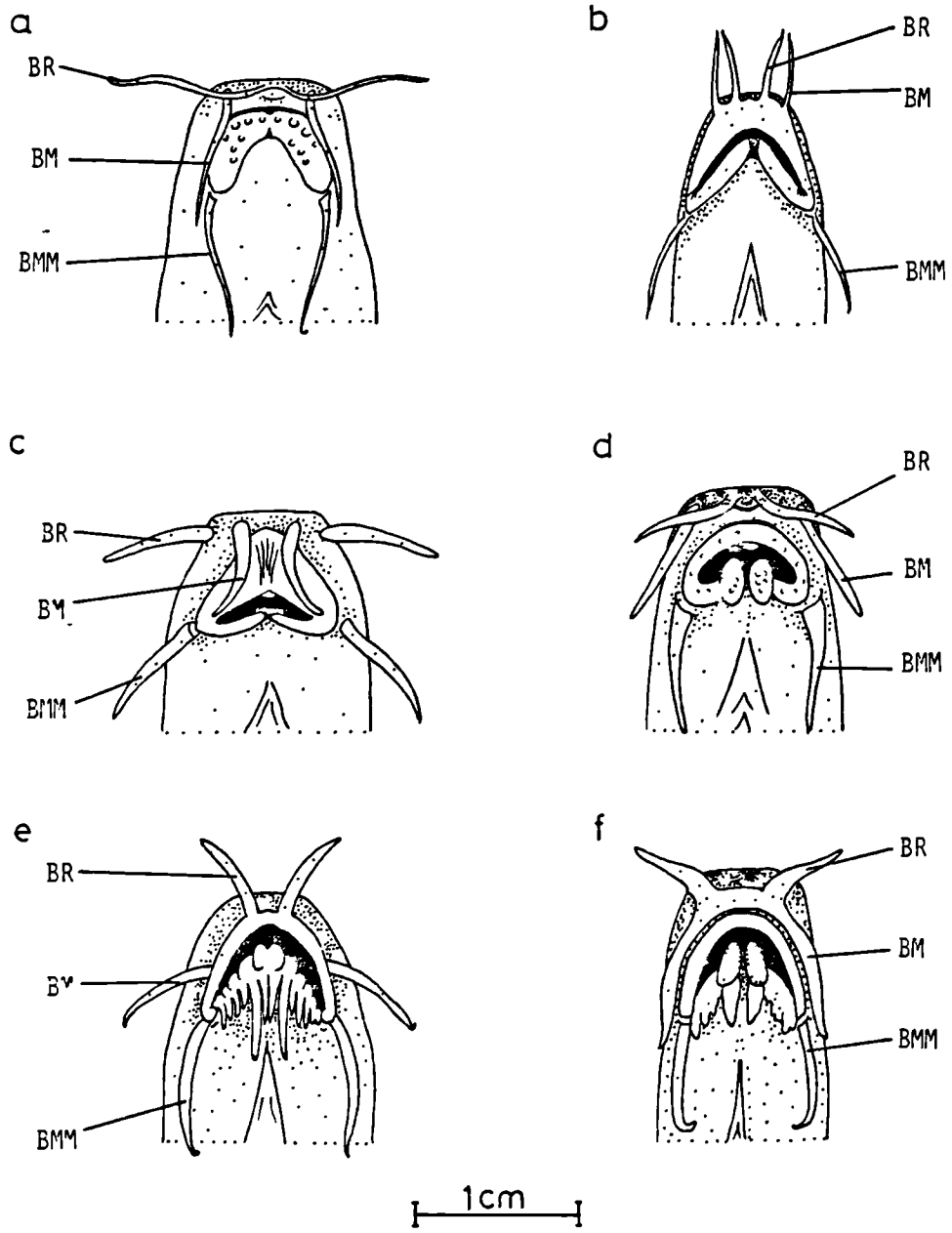
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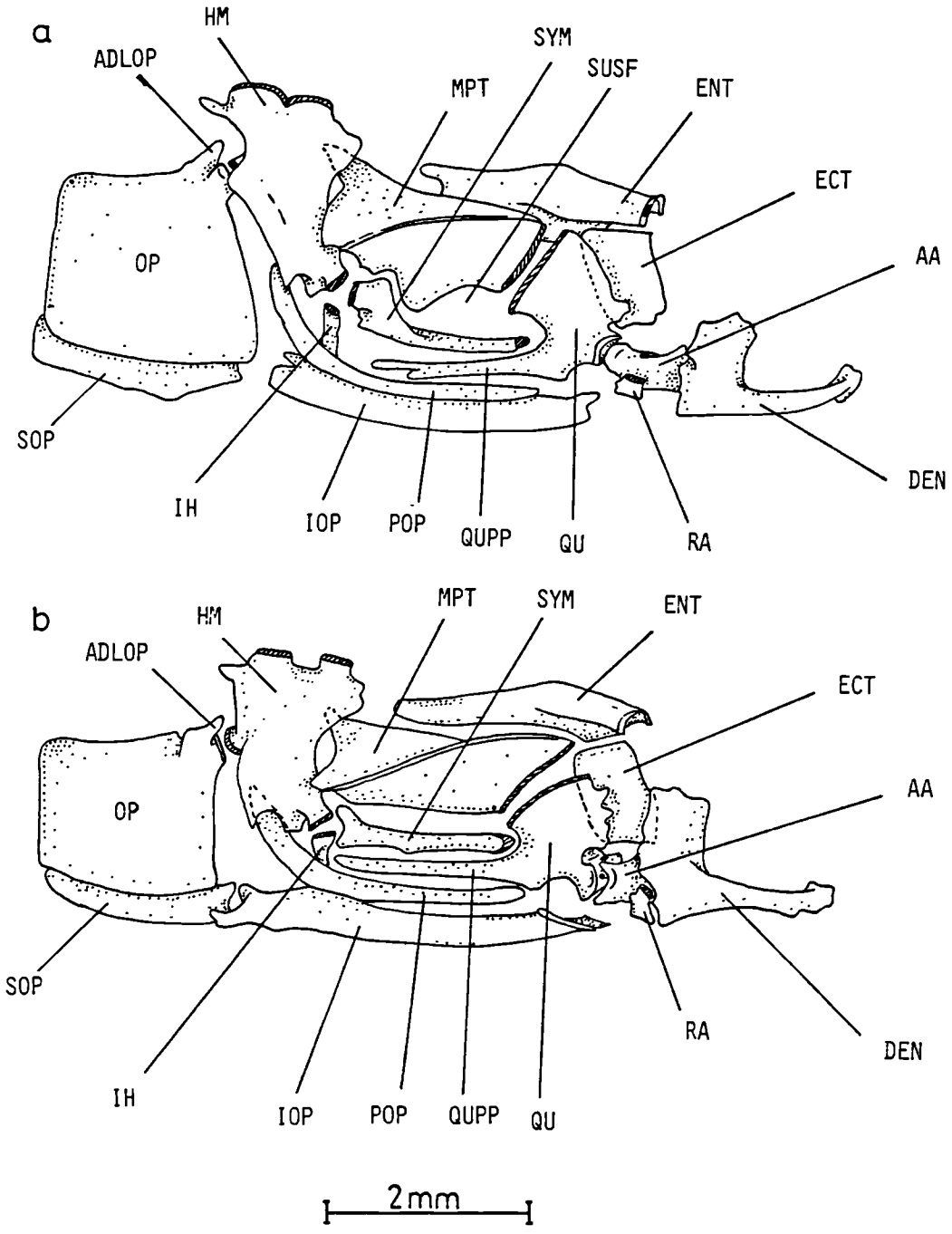
Fig. ii Suspensorium and opercular series

(Right lateral view)

a. Orthrias tschaiyssuensis

b. Noemacheilus rupecola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QUPP
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2mm

Fig. iii *Adductor mandibulae* and related structures

a. *Noemacheilus denisoni*

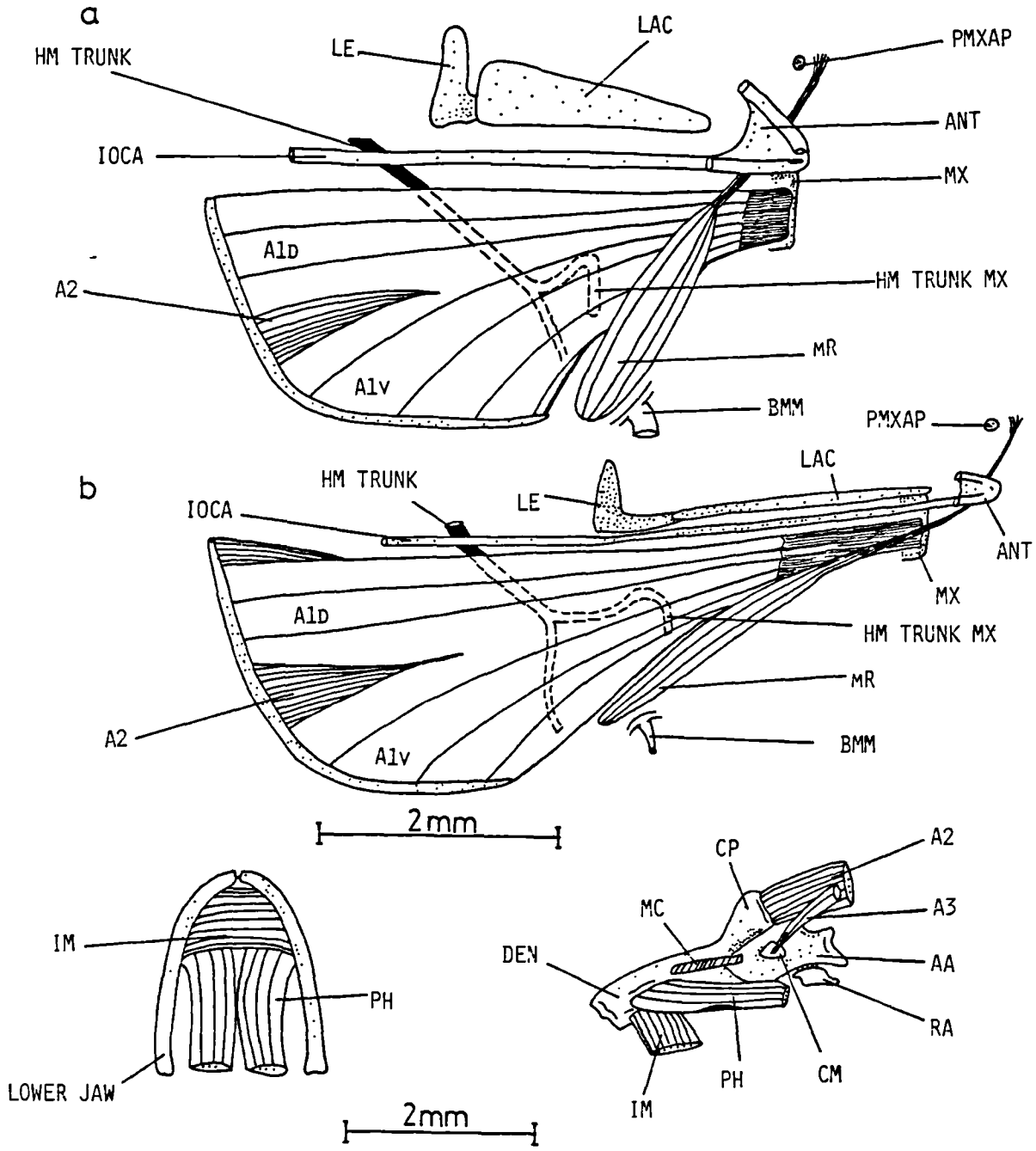
[Right lateral view]

b. *Noemacheilus yarkandensis*

above right lateral view

below left ventral view

below right medial view, right half of lower jaw.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HM TRUNK
LE
LAC
PMXAP
ANT
IOCA
MX
A1D
A2
HM TRUNK MX
MR
A1V
BMM
b
HM TRUNK
LE
LAC
PMXAP
IOCA
ANT
MX
A1D
HM TRUNK MX
MR
A2
A1V
BMM
2mm
IM
PH
LOWER JAW
2mm
CP
A2
MC
A3
DEN
AA
RA
PH
CM
IM

Fig. iv *Adductor mandibulae* and related structures

[Right lateral view]

a. *Noemacheilus gracilis*

b. *Noemacheilus stoliczski*

c. *Oronectes platycephalus*

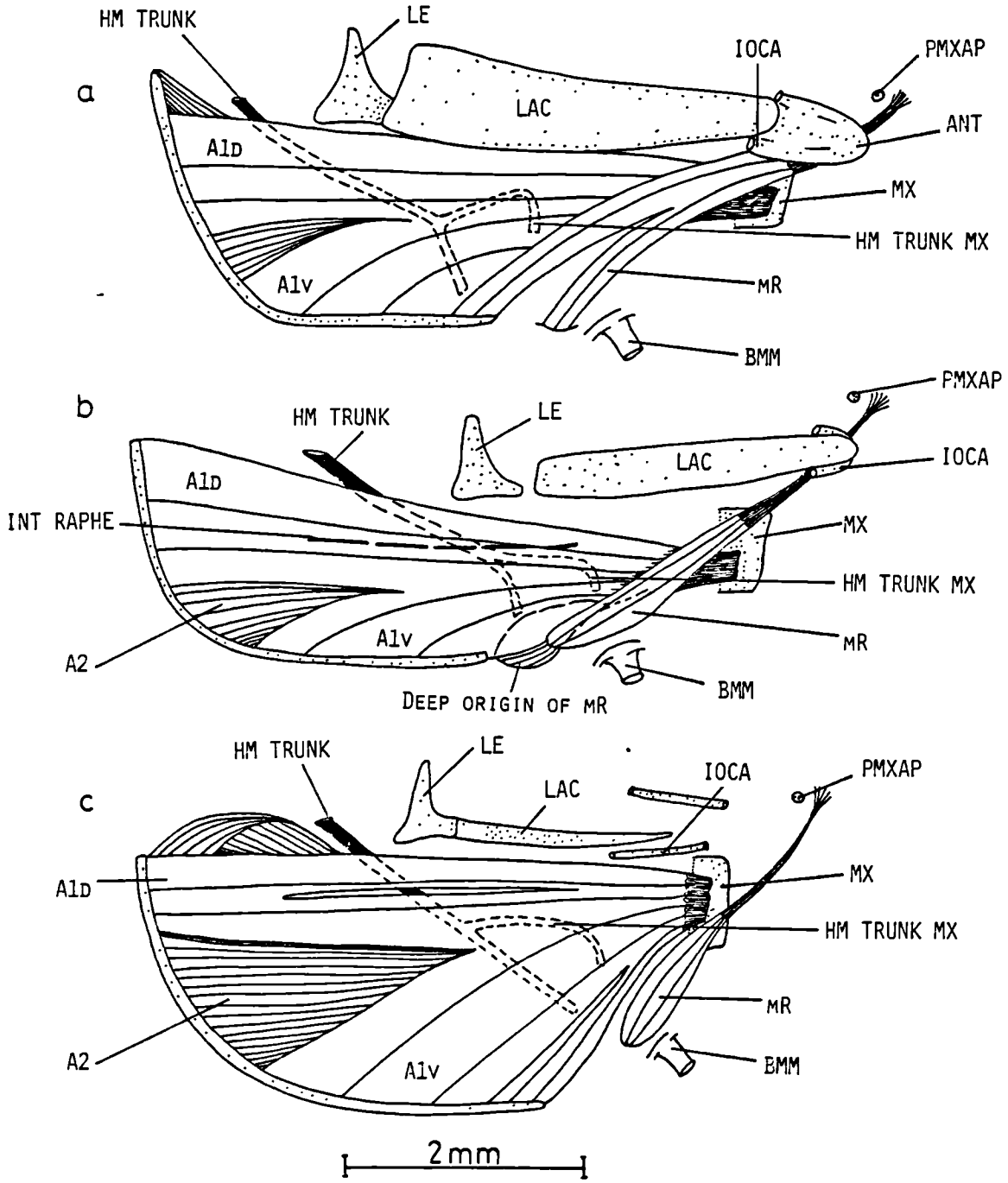

a
HM TRUNK
LE
IOCA
PMXAP
LAC
ANT
A1D
MX
HM TRUNK MX
A1V
MR
BMM
b
PMXAP
HM TRUNK
LE
LAC
IOCA
A1D
INT RAPHE
MX
HM TRUNK MX
MR
A1V
A2
BMM
DEEP ORIGIN OF MR
c
HM TRUNK
LE
IOCA
PMXAP
LAC
A1D
MX
HM TRUNK MX
MR
A2
A1V
BMM
2mm

Fig. v *Adductor mandibulae* and related structures

(Right lateral view)

a. *Glaniopsis hanitschi*

b. *Gastromyzon borneensis*

c. *Balitora brucei*

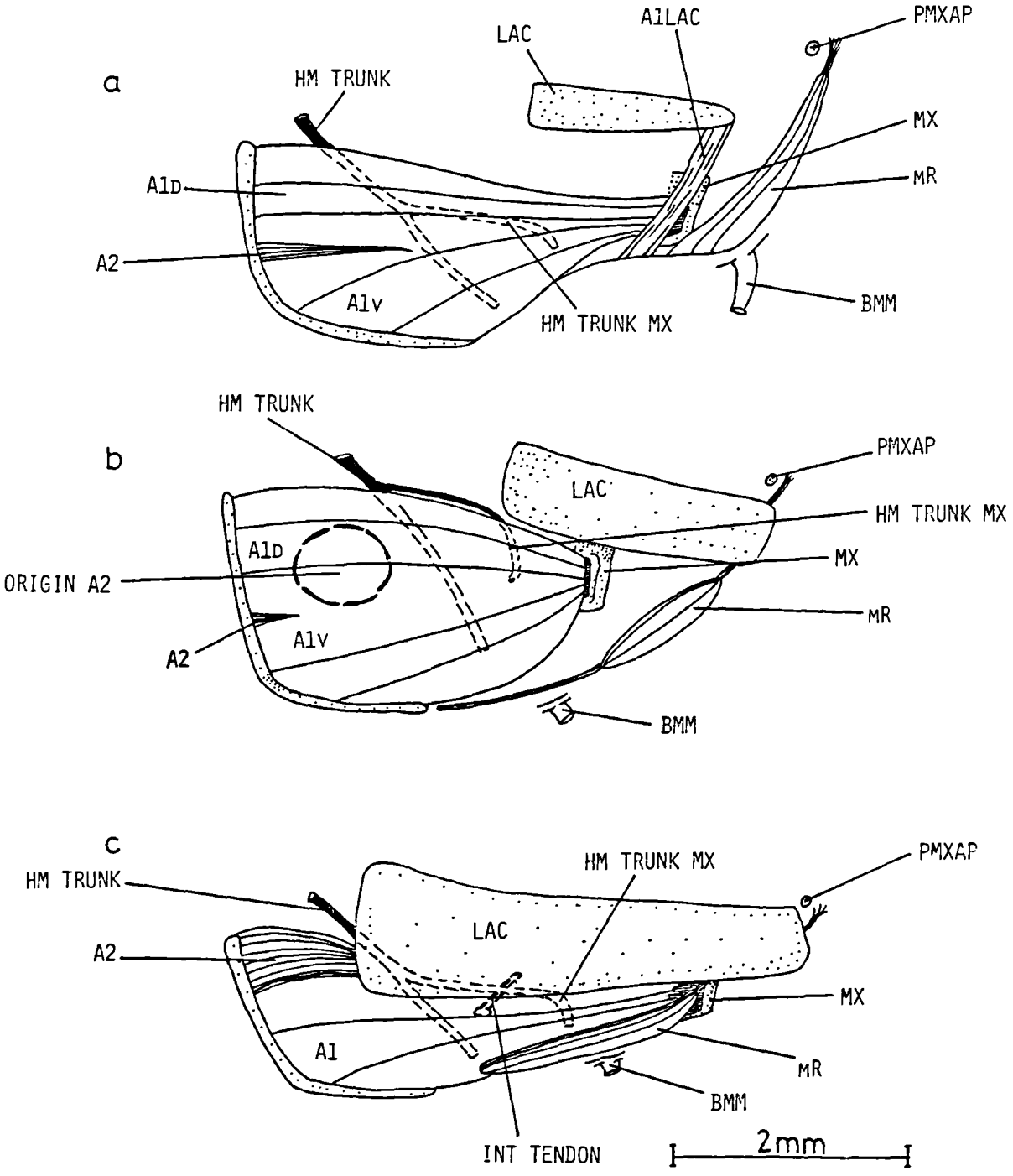

a
HM TRUNK
LAC
A1LAC
PMXAP
MX
MR
A1D
A2
A1V
HM TRUNK MX
BMM
b
HM TRUNK
PMXAP
LAC
HM TRUNK MX
A1D
ORIGIN A2
MX
MR
A1V
A2
BMM
c
HM TRUNK
HM TRUNK MX
PMXAP
A2
LAC
MX
A1
MR
BMM
INT TENDON
2mm

Fig. vi *Adductor mandibulae* and related structures

(Right lateral view)

a. *Ellopostoma*

b. *Vaillantella flavofasciata*

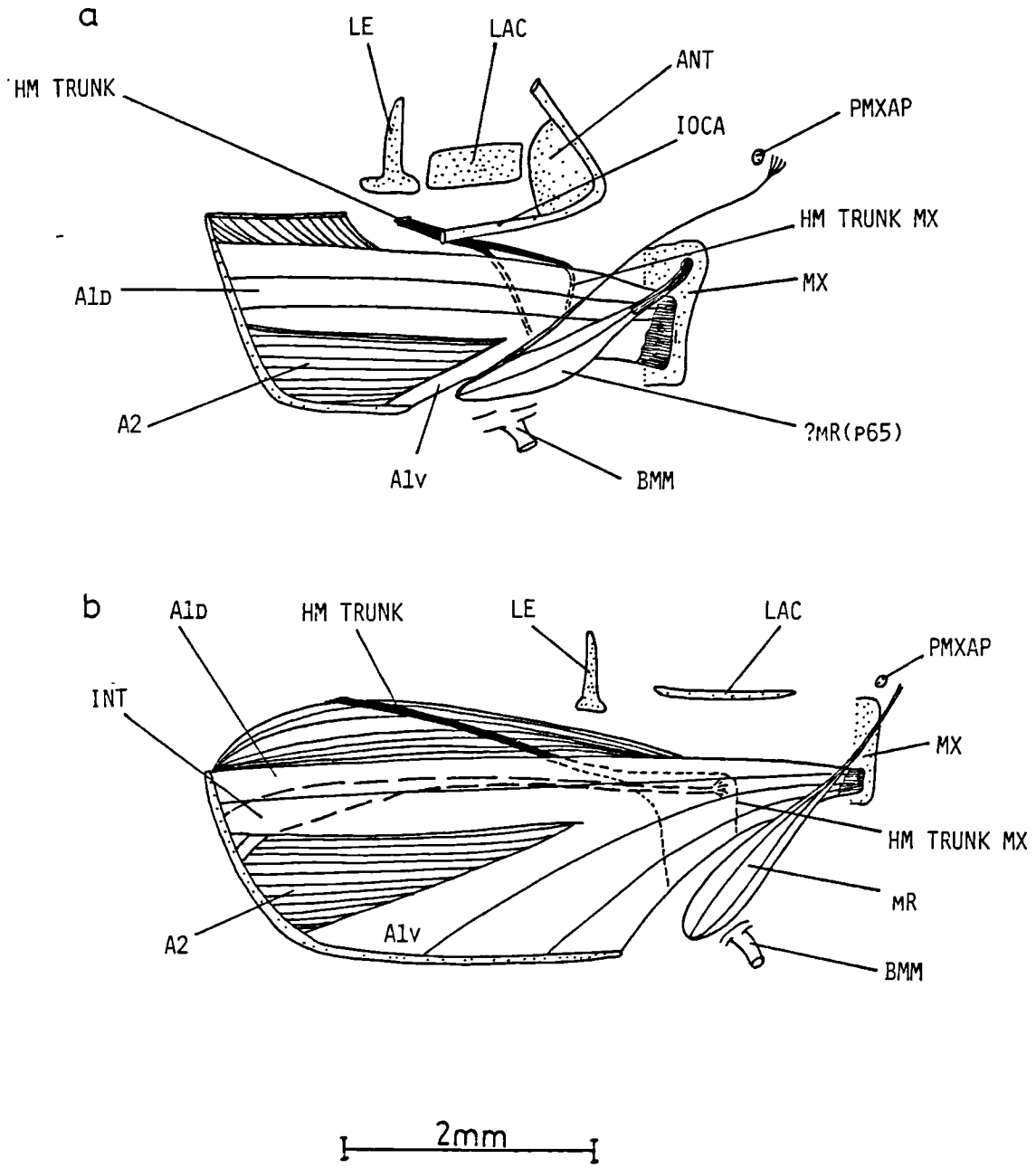

a
LE
LAC
ANT
HM TRUNK
IOCA
PMXAP
HM TRUNK MX
MX
A1D
A2
?MR(P65)
A1v
BMM
b
A1D
HM TRUNK
LE
LAC
PMXAP
INT
MX
HM TRUNK MX
MR
A2
A1v
BMM
2mm

Fig. vii Suspensorium and opercular series

(Right lateral view)

a. *Misgurnus anguillicaudatus*

b. *Lepidocephalus annandali*

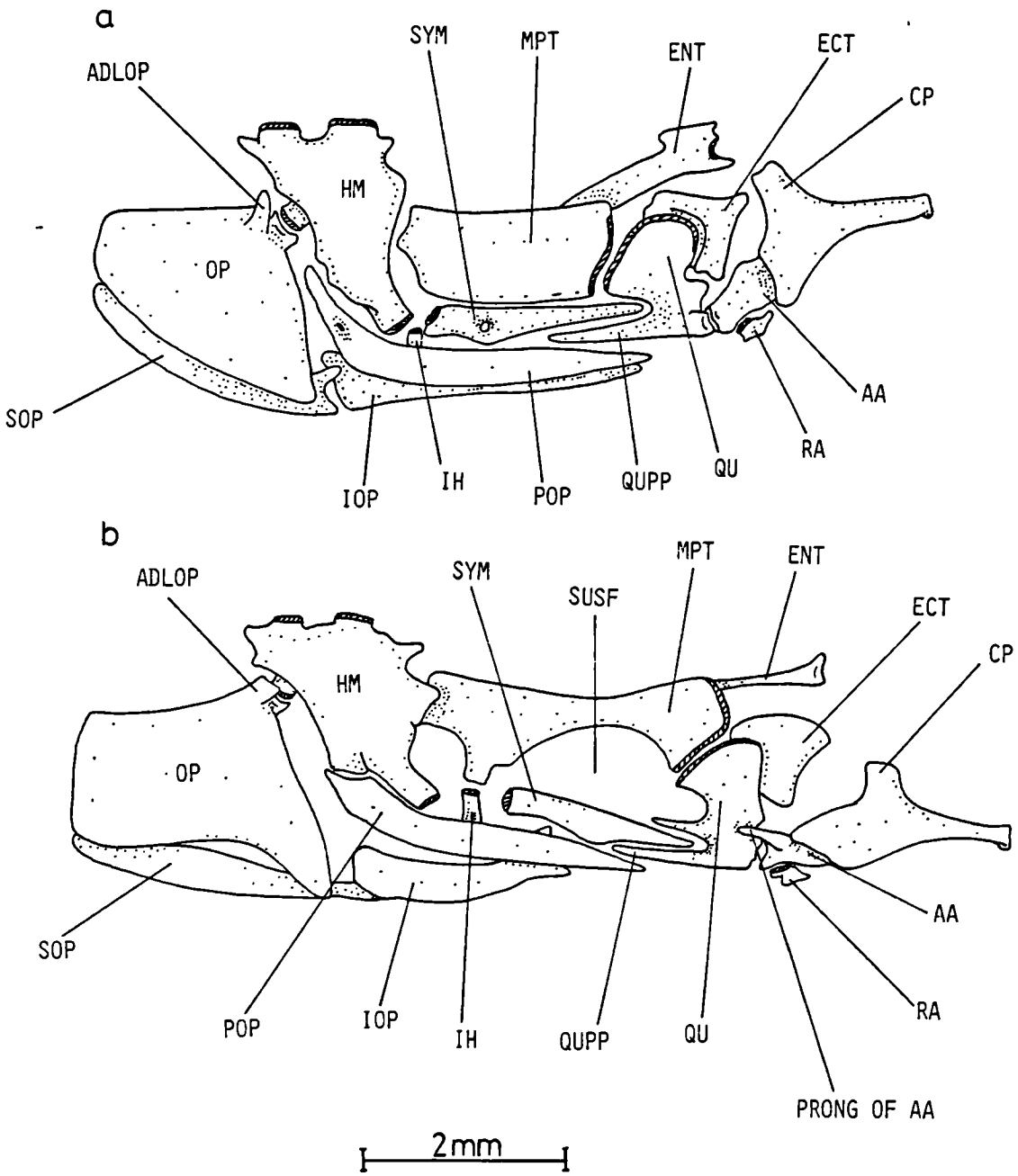

a
ADLOP
SYM
MPT
ENT
ECT
CP
HM
OP
SOP
IOP
IH
POP
QUPP
QU
RA
AA
b
ADLOP
SYM
SUSF
MPT
ENT
ECT
CP
HM
OP
SOP
POP
IOP
IH
QUPP
QU
PRONG OF AA
RA
AA
2mm

Fig. viii Adductor mandibulae and related structures

(Right lateral view)

a. Misgurnus fossilis

b. Misgurnus mizolepis

c. Misgurnus dabryanus

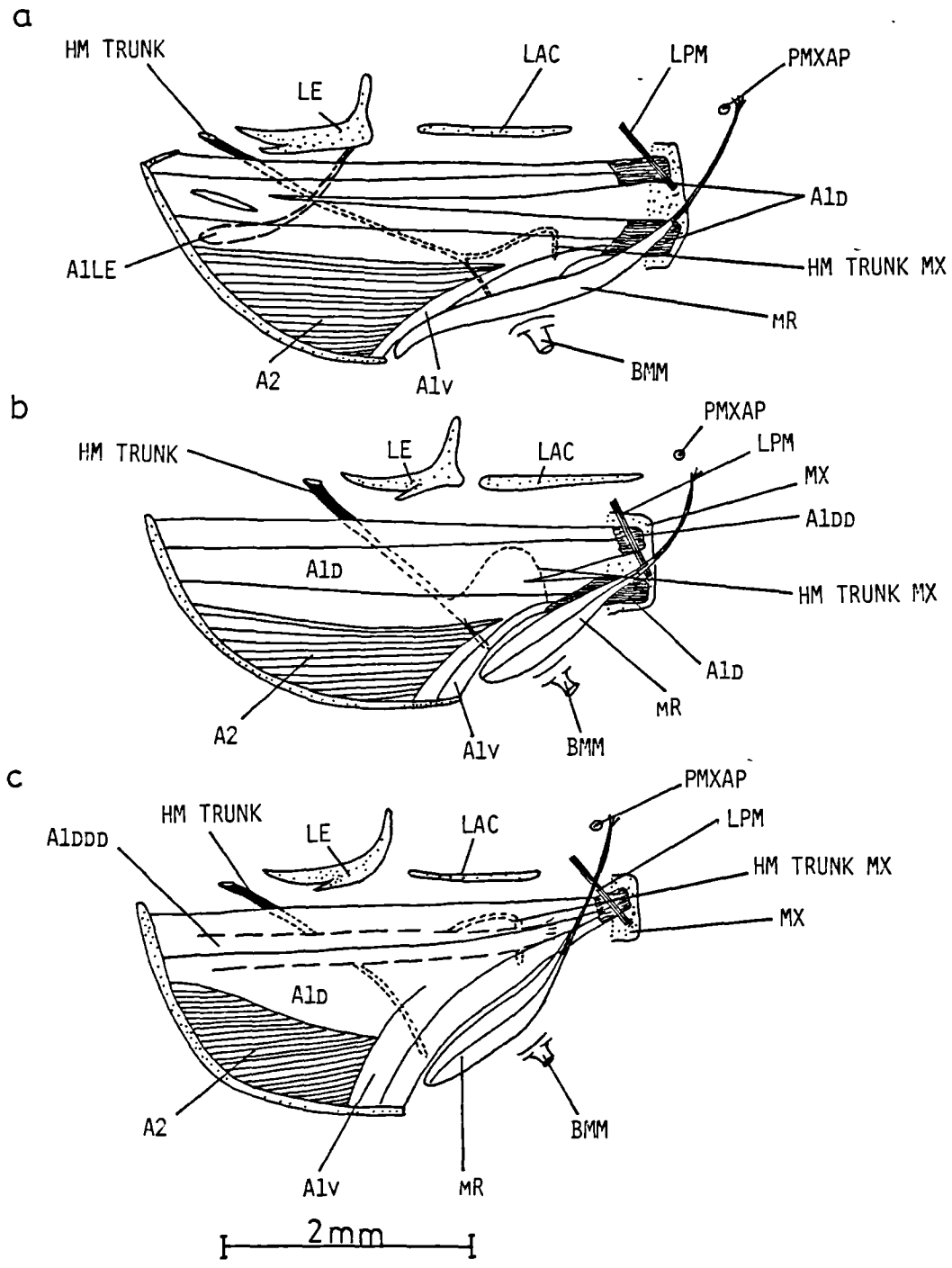

a
HM TRUNK
LE
LAC
LPM
PMXAP
A1D
A1LE
HM TRUNK MX
MR
BMM
A2
A1v
b
PMXAP
HM TRUNK
LE
LAC
LPM
MX
A1DD
A1D
HM TRUNK MX
A1D
MR
A2
A1v
BMM
c
PMXAP
A1DDD
HM TRUNK
LE
LAC
LPM
HM TRUNK MX
MX
A1D
A2
BMM
A1v
MR
2mm

Fig. ix *Adductor mandibulae* and related structures

[Right lateral view]

a. *Acanthophthalmus semicinctus*

b. *Somileptes gongota*

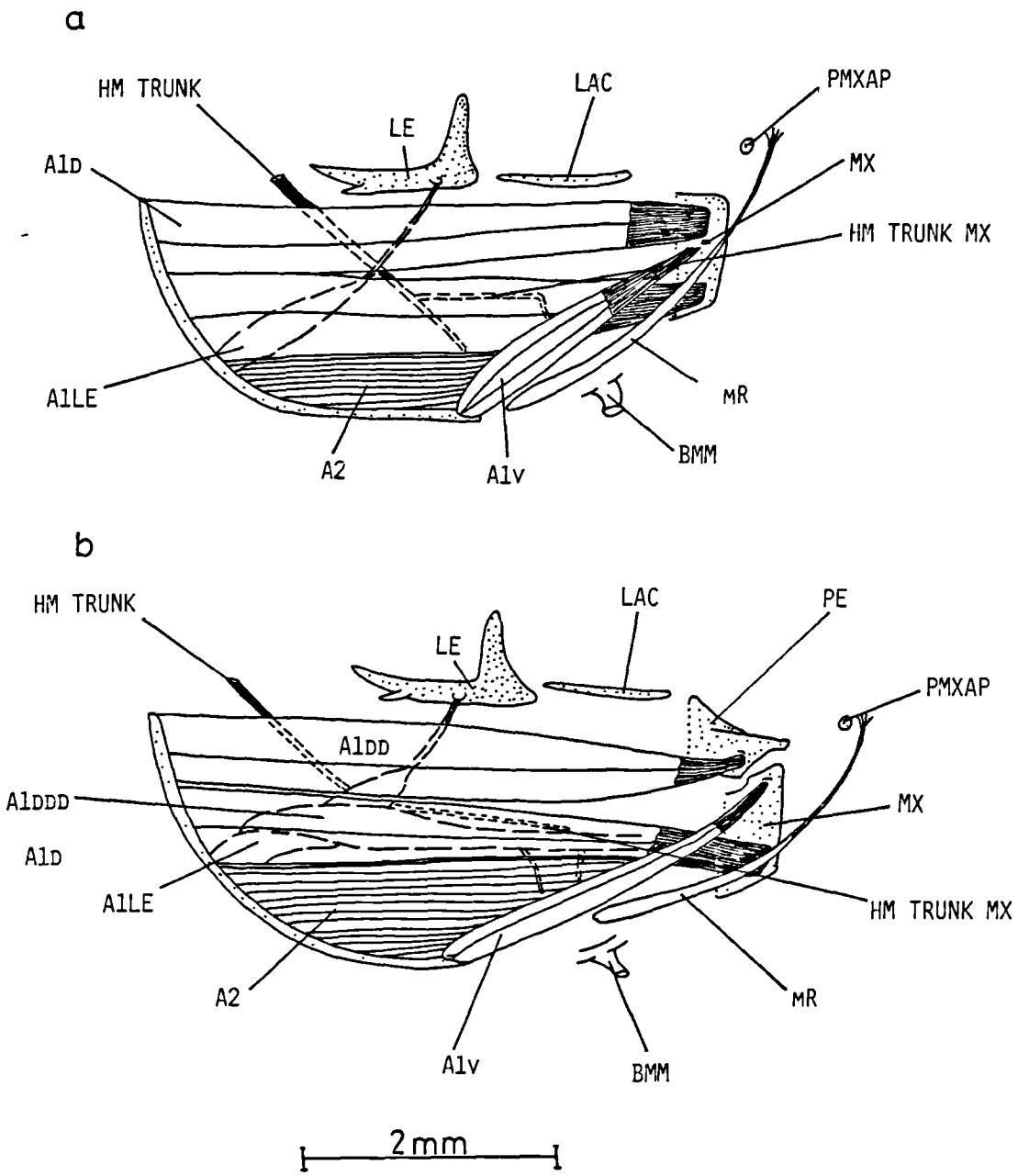

a
HM TRUNK
LE
LAC
PMXAP
A1D
MX
HM TRUNK MX
A1LE
MR
BMM
A2
A1v
b
HM TRUNK
LAC
PE
LE
PMXAP
A1DD
A1DDD
MX
A1D
A1LE
HM TRUNK MX
A2
MR
A1v
BMM
2mm

Fig. x *Adductor mandibulae* and related structures

(Right lateral view)

a. *Niwaella delicta*

b. *Acanthopsis choirorhynchus*

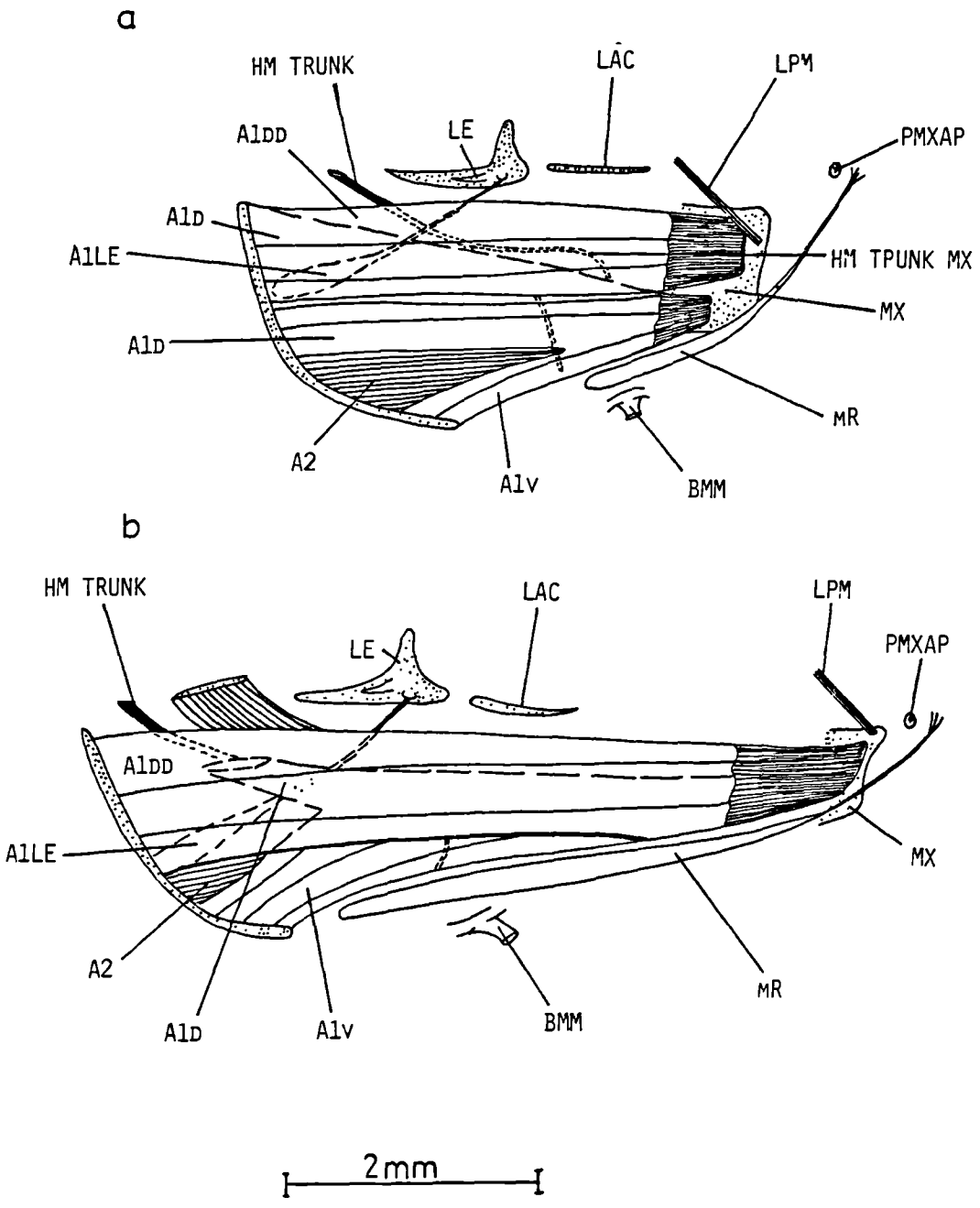

a
HM TRUNK
LAC
LPM
A1DD
LE
PMXAP
A1D
A1LE
HM TPUNK MX
MX
A1D
MR
A2
A1v
BMM
b
HM TRUNK
LAC
LPM
LE
PMXAP
A1DD
A1LE
MX
A2
MR
A1D
A1v
BMM
2mm

Fig. xi *Adductor mandibulae* and related structures

(Right lateral view)

a. *Lepidocephalus guntea*

b. *Lepidocephalus annandali*

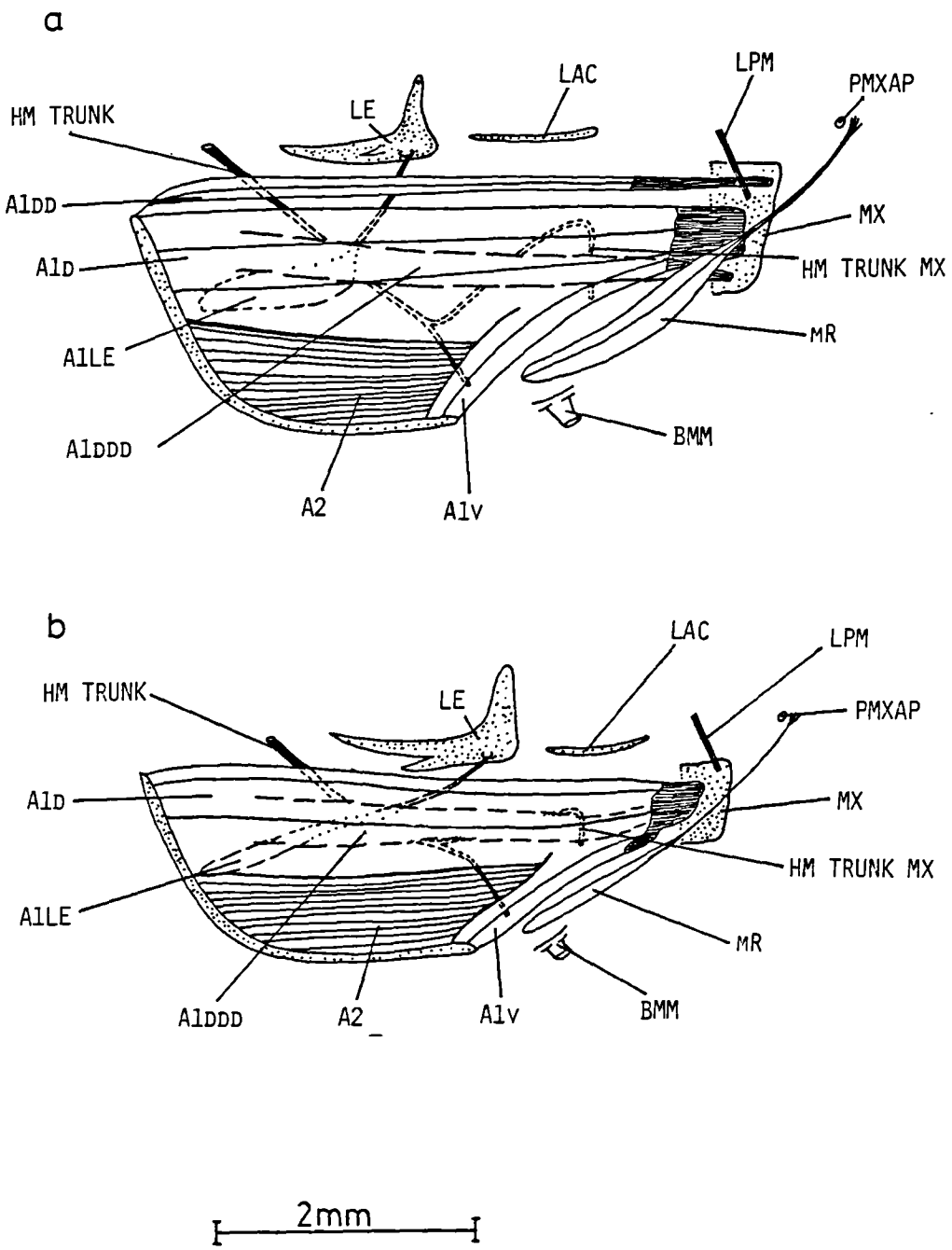

a
HM TRUNK
LE
LAC
LPM
PMXAP
A1DD
MX
A1D
HM TRUNK MX
MR
A1LE
A1DDD
BMM
A2
A1V
b
HM TRUNK
LE
LAC
LPM
PMXAP
A1D
MX
HM TRUNK MX
A1LE
MR
A1DDD
A2
A1V
BMM
2mm

Fig. xii *Adductor mandibulae* and related structures

(Right lateral view)

a. *Leptobotia pratti*

b. *Leptobotia fasciata*

c. *Leptobotia elongata*

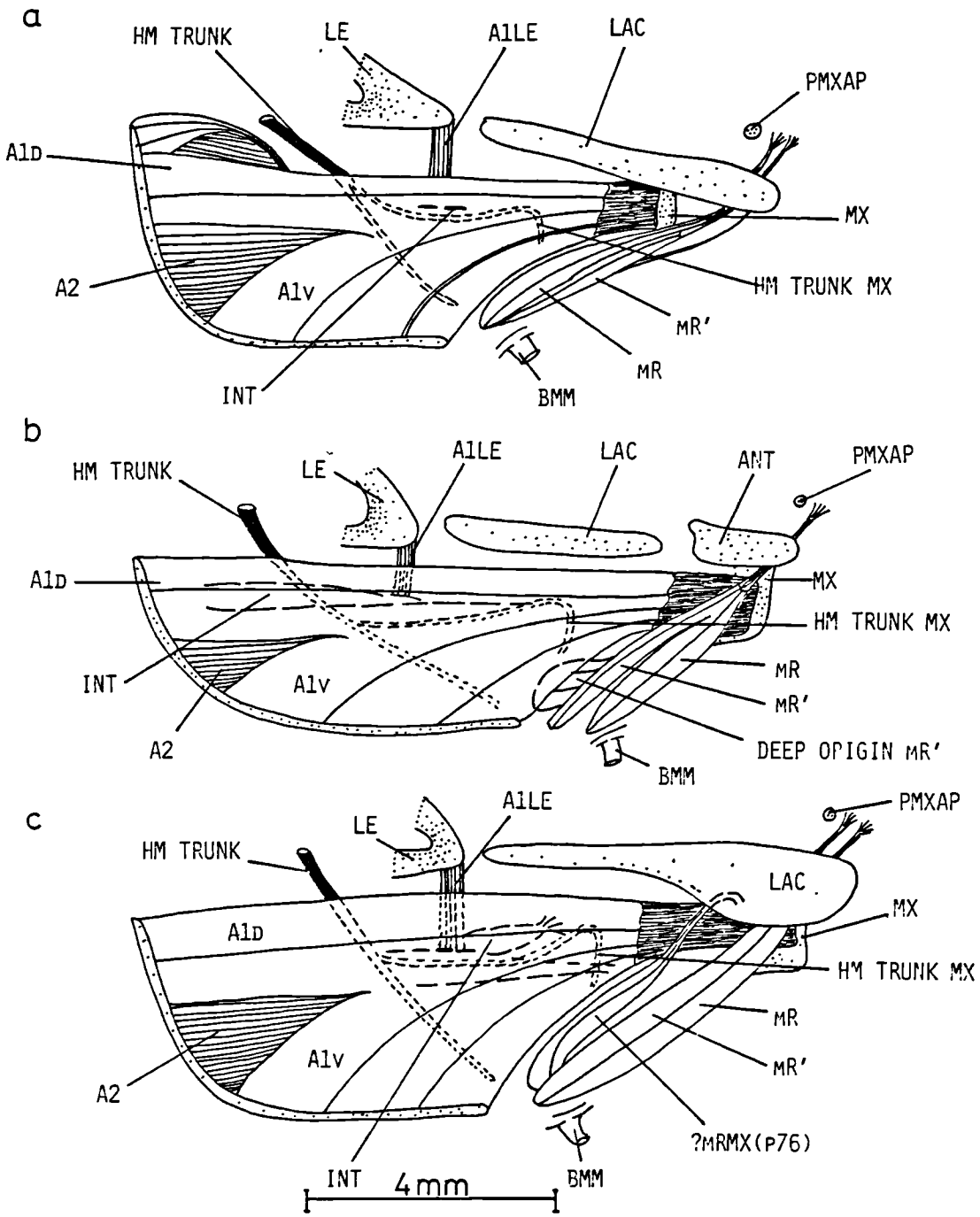

a
HM TRUNK
LE
A1LE
LAC
PMXAP
A1D
MX
A2
A1V
HM TRUNK MX
MR'
MR
INT
BMM
b
HM TRUNK
LE
A1LE
LAC
ANT
PMXAP
A1D
MX
HM TRUNK MX
INT
A1V
MR
MR'
A2
DEEP ORIGIN MR'
BMM
c
A1LE
PMXAP
LE
HM TRUNK
LAC
MX
A1D
HM TRUNK MX
MR
A1V
MR'
A2
?MRMX(P76)
INT
4mm
BMM

Fig. xiii *Adductor mandibulae* and related structures

(Right lateral view)

a. *Botia macracantha*

b. *Botia modesta*

c. *Botia superciliaris*

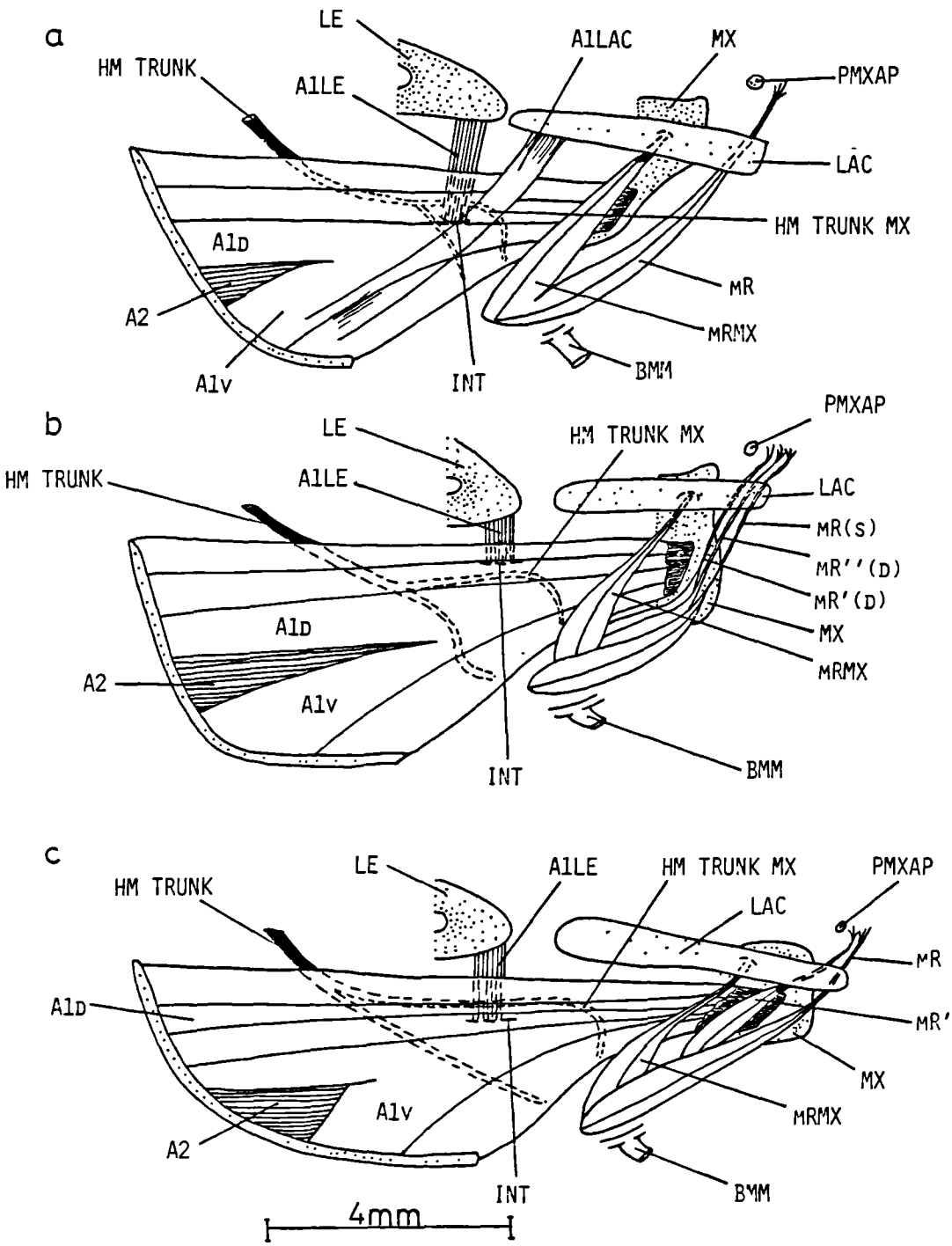

a
LE
A1LAC
MX
PMXAP
HM TRUNK
A1LE
LAC
HM TRUNK MX
A1D
MR
A2
MRMX
BMM
A1v
INT
b
PMXAP
LE
HM TRUNK MX
HM TRUNK
A1LE
LAC
MR(S)
MR''(D)
MR'(D)
A1D
MX
A2
MRMX
A1v
INT
BMM
c
LE
A1LE
HM TRUNK MX
PMXAP
HM TRUNK
LAC
MR
A1D
MR'
MX
A1v
MRMX
A2
INT
BMM
4mm

Fig. xiv Adductor mandibulae and related structures

[Right lateral view]

a. Barilius bendelisis

b. Abbottina rivularis

c. Pseudogobio esocinus

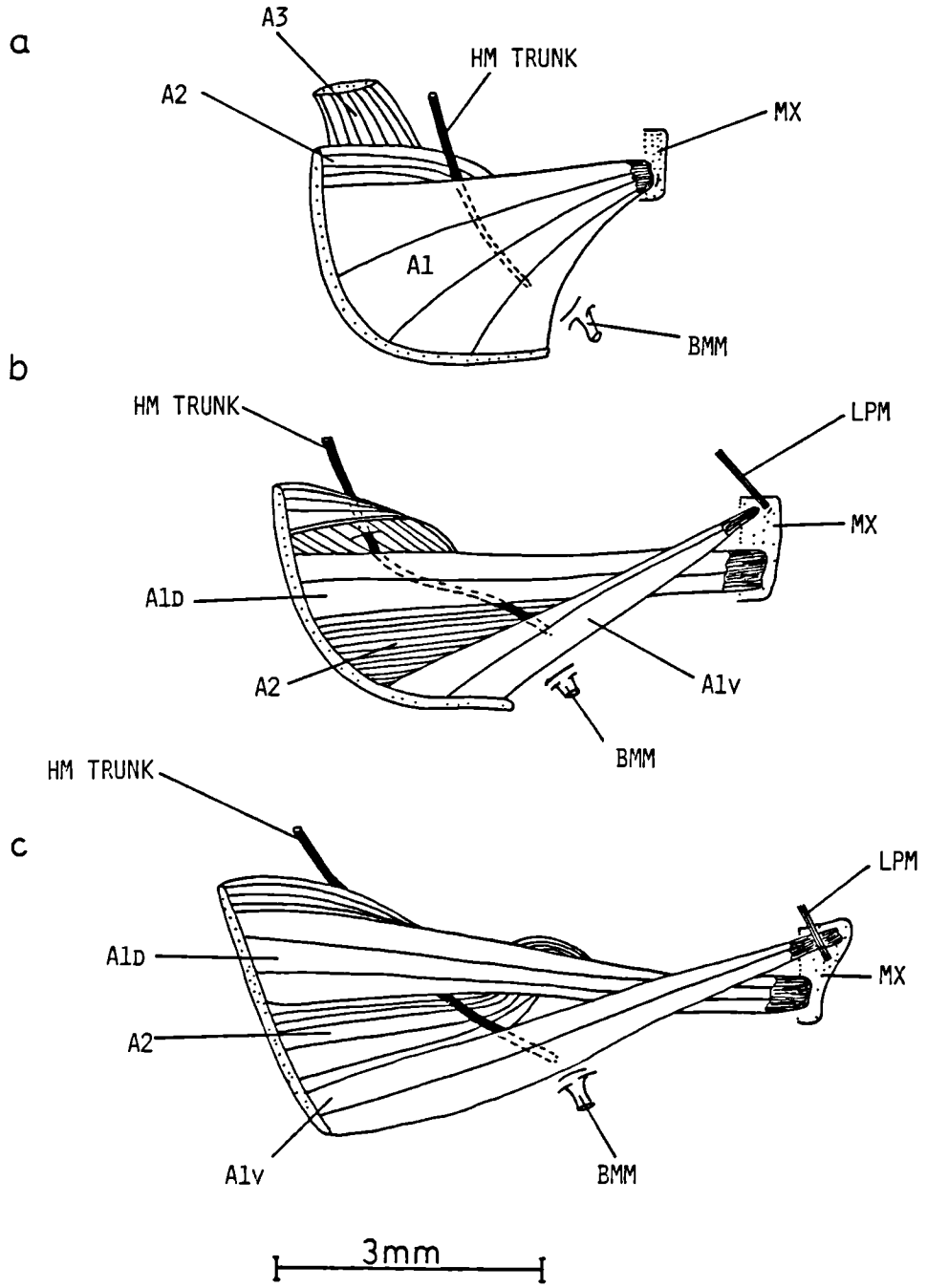

a
A3
HM TRUNK
A2
MX
A1
BMM
b
HM TRUNK
LPM
MX
A1D
A2
A1v
BMM
HM TRUNK
c
LPM
A1D
MX
A2
A1v
BMM
3mm

Fig. xv *Adductor mandibulae* and related structures

[Right lateral view]

a. *Gyrinocheilus aymonieri*

b. *Psilorhynchus balitora*

c. *Catostomus catostomus*

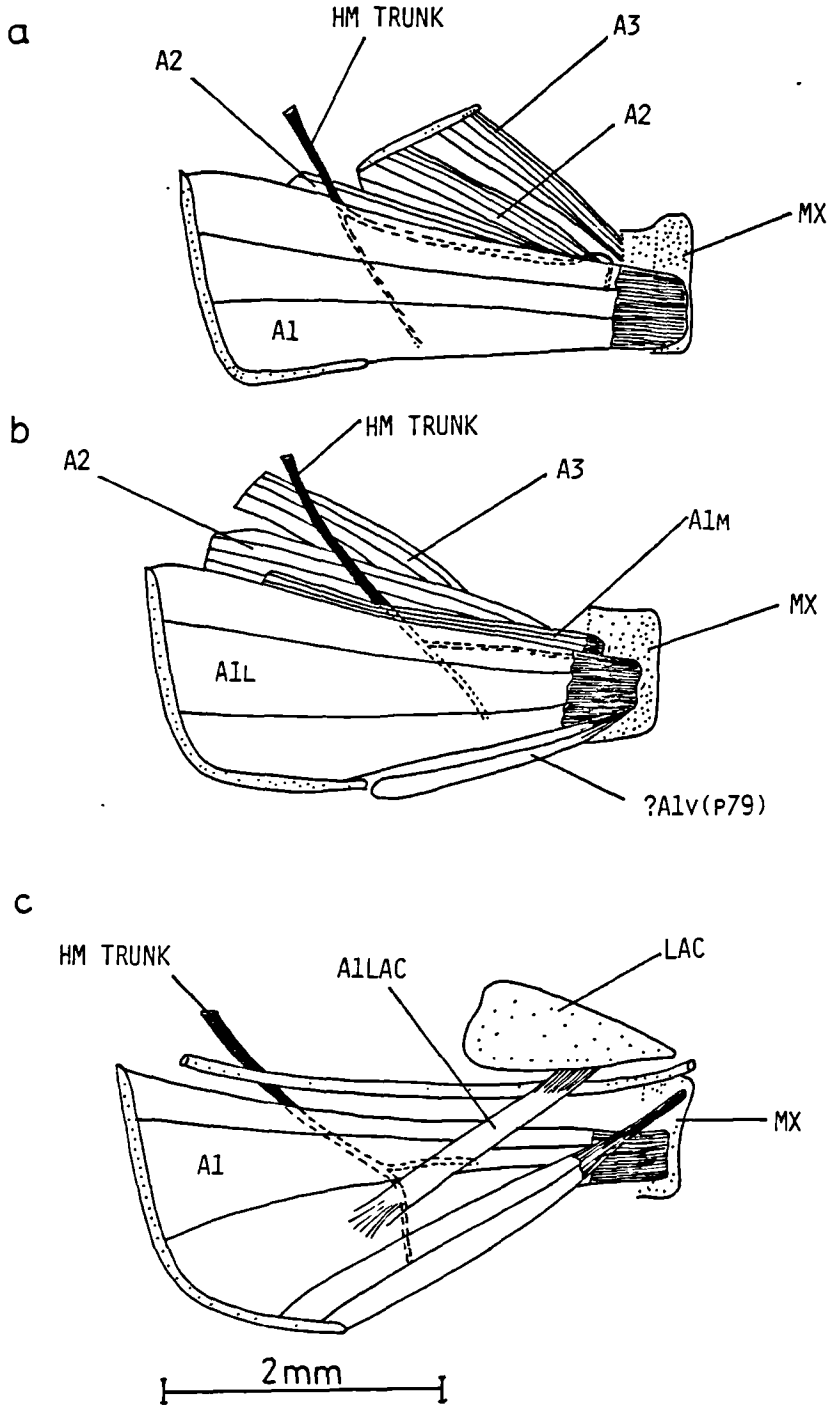

a
HM TRUNK
A3
A2
A2
MX
A1
b
HM TRUNK
A2
A3
A1M
MX
A1L
?A1v(P79)
c
HM TRUNK
A1LAC
LAC
MX
A1
2mm

Fig. xvi Branching diagram showing preliminary hypothesis of relationships of cobitoids [excluding *Ellopostoma* and *Vaillantella*] based on characters of the *adductor mandibulae* and related structures.

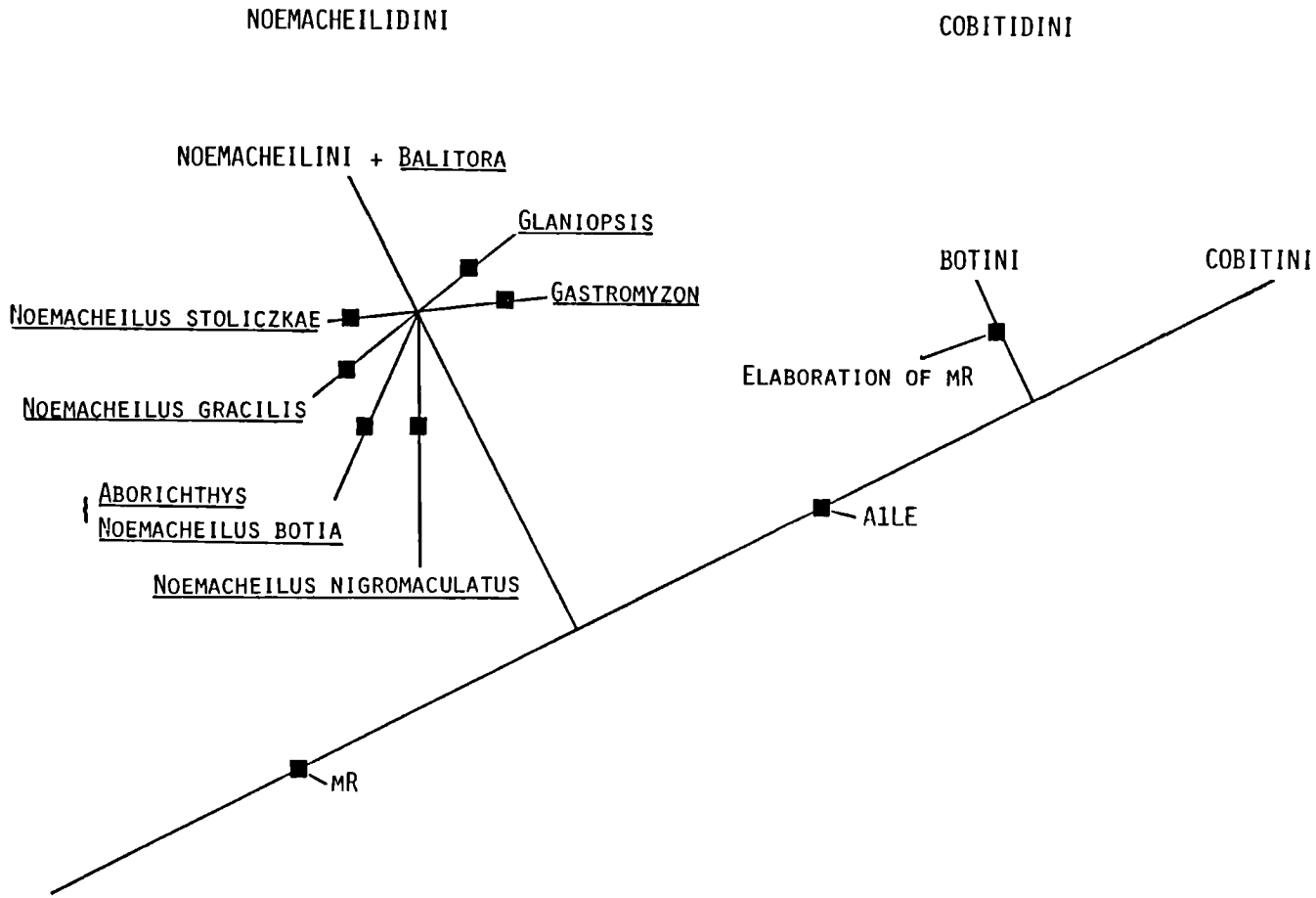
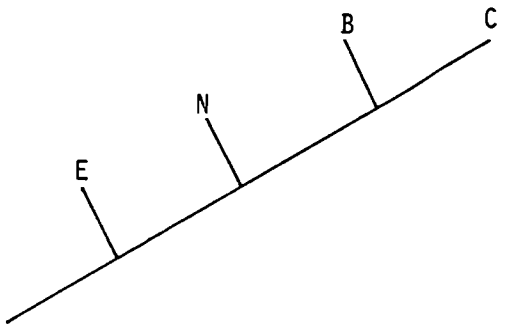
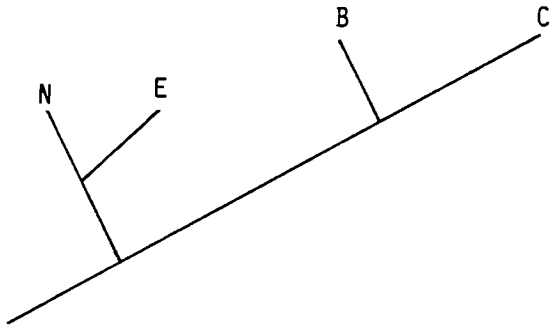

NOEMACHEILIDINI
COBITIDINI
NOEMACHEILINI + BALITORA
GLANIOPSIS
GASTROMYZON
NOEMACHEILUS STOLICZKAE
NOEMACHEILUS GRACILIS
ABORICHTHYS
NOEMACHEILUS BOTIA
NOEMACHEILUS NIGROMACULATUS
BOTINI
COBITINI
ELABORATION OF MR
AILE
MR

Fig. xvii Possible hypotheses of the phylogenetic position of *Ellopostoma*

a



b



c

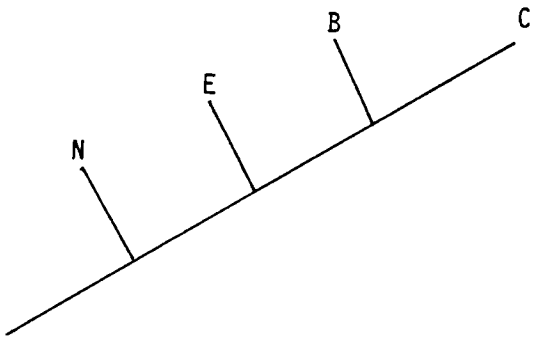


Fig. xviii Diagrammatic figures illustrating production of the INT division of the A1 [Left lateral view]

a. Misgurnus

b. Cobitis

c. Vaillantella

d. Hymenophysa

e. Lefua

a,b,c and e are redrawn from Takahasi [1925]

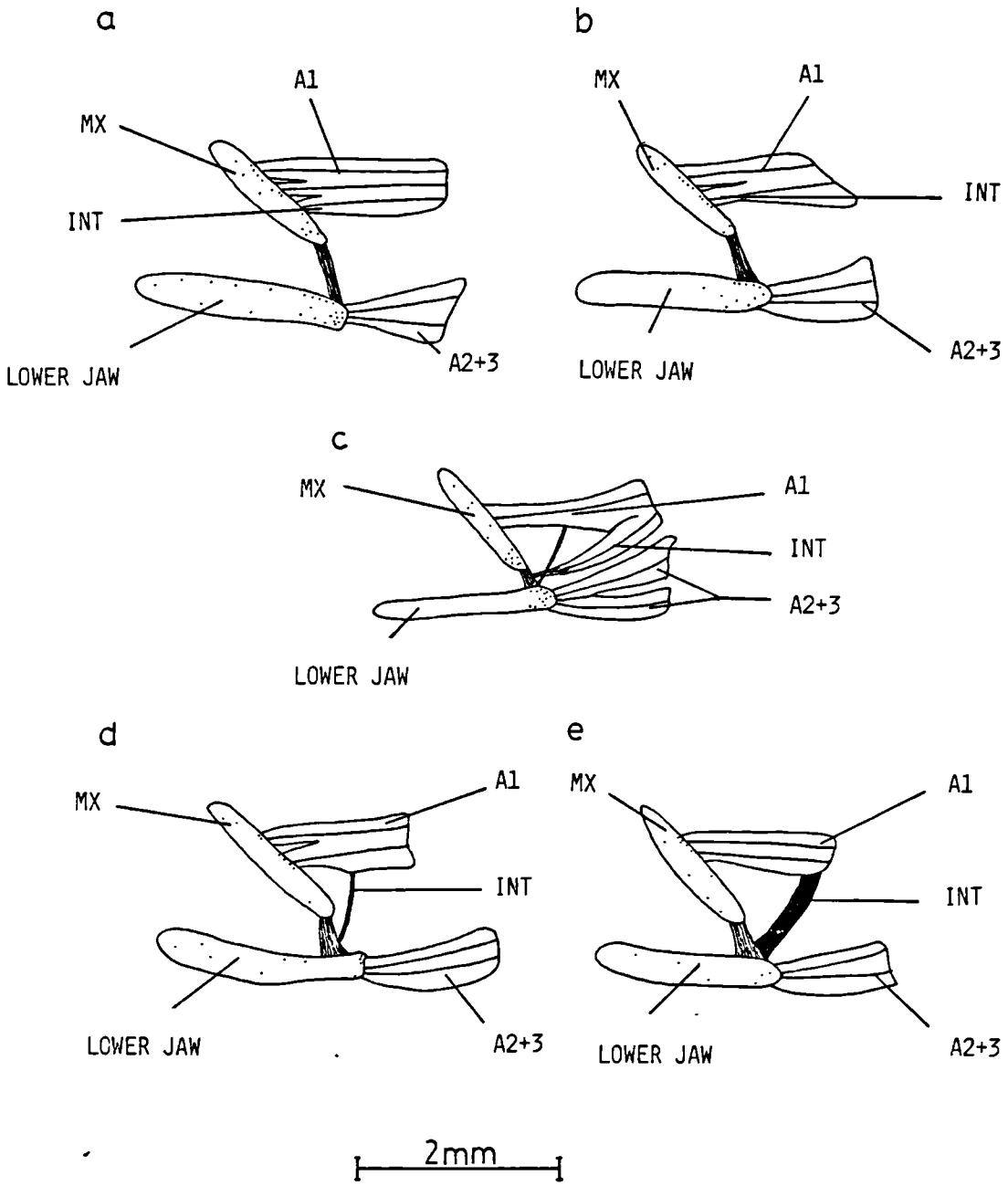
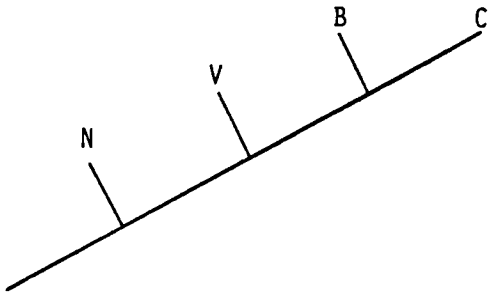
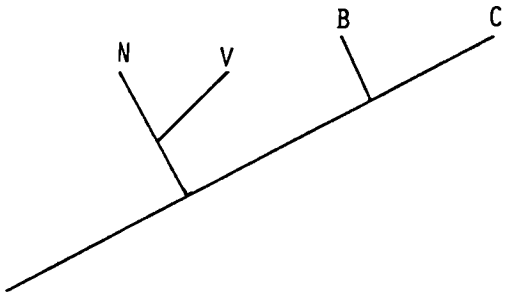

a
A1
MX
INT
LOWER JAW
A2+3
b
MX
A1
INT
LOWER JAW
A2+3
c
MX
A1
INT
A2+3
LOWER JAW
d
MX
A1
INT
LOWER JAW
A2+3
e
MX
A1
INT
LOWER JAW
A2+3
2mm

Fig. xix Possible hypotheses of the phylogenetic position of Vaillantella.
c is the interpretation of Nalbant & Banarescu [1977]

a



b



c

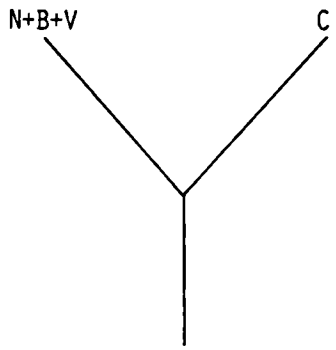


Fig. xx Branching diagram showing preliminary hypothesis of the relationships of the Cobitini based on characters of the adductor mandibulae and related structures.

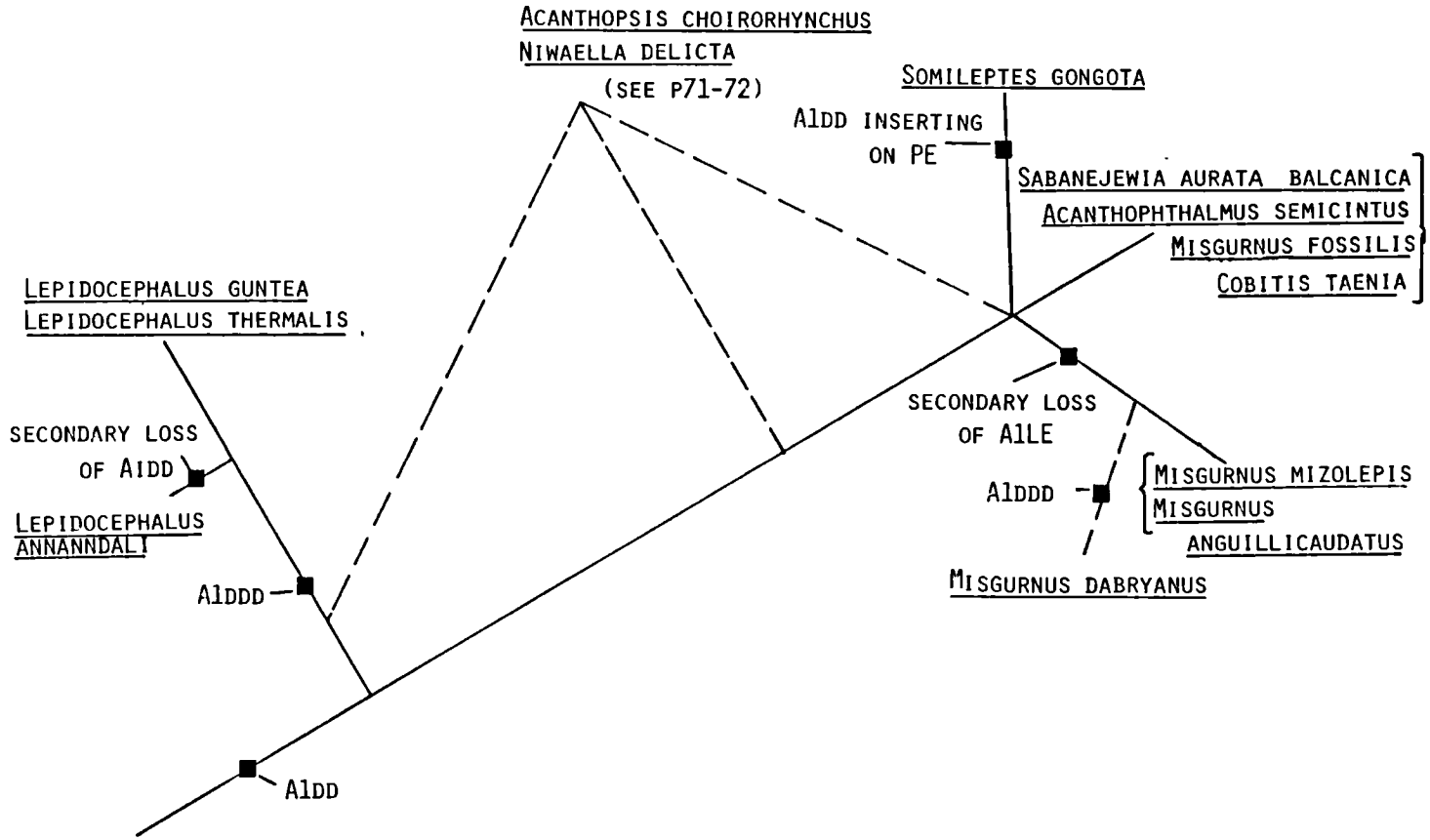
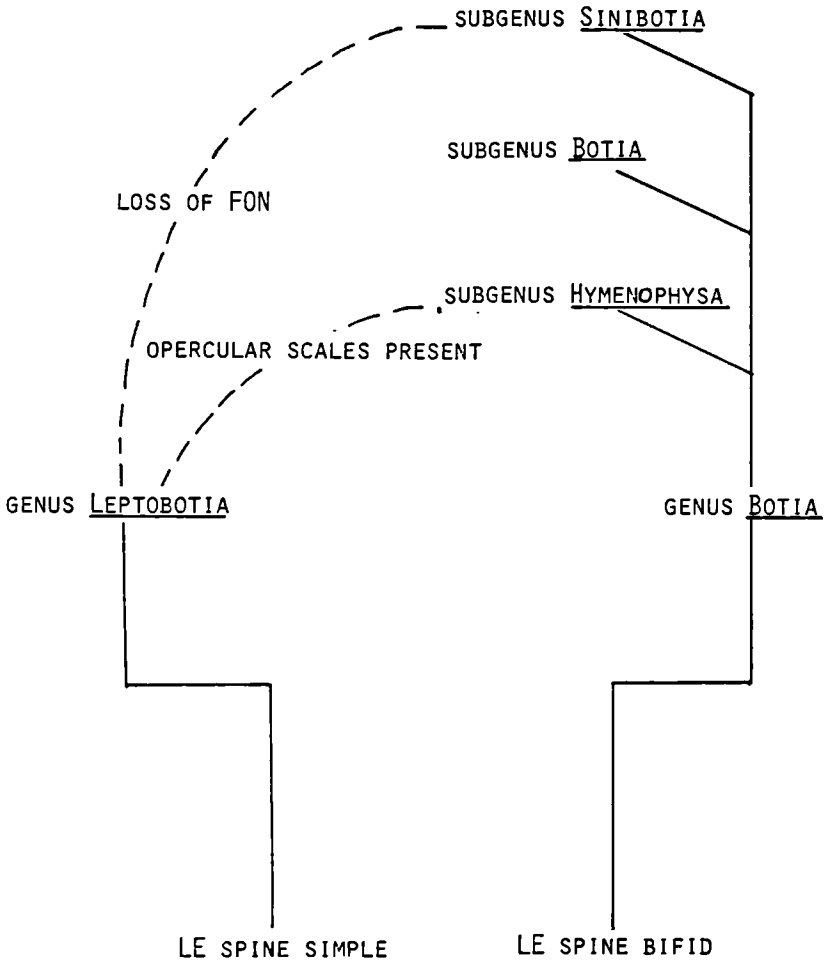

ACANTHOPSIS CHOIRORHYNCHUS
NIWAELLA DELICTA
(SEE P71-72)
SOMILEPTES GONGOTA
A1DD INSERTING
ON PE
SABANEJEWIA AURATA BALCANICA
ACANTHOPHTHALMUS SEMICINTUS
MISGURNUS FOSSILIS
COBITIS TAENIA
LEPIDOCEPHALUS GUNTEA
LEPIDOCEPHALUS THERMALIS
SECONDARY LOSS
OF A1DD
LEPIDOCEPHALUS
ANNANNDALI
A1DDD
A1DD
SECONDARY LOSS
OF A1LE
A1DDD
MISGURNUS MIZOLEPIS
MISGURNUS
ANGUILLICAUDATUS
MISGURNUS DABRYANUS

Fig. xxi Scheme for the relationships of Botia and Leptobotia proposed by Fang (1936)



HYPOTHESIS IS THAT BOTIA AND LEPTOBOTIA HAVE EVOLVED IN PARALLEL. CRITICAL SEPARATION IS ON THE NATURE OF THE LE SPINE(FOLLOWING HORA 1922)

Fig. xxii Scheme for the relationships of Botia proposed by Taki (1972)

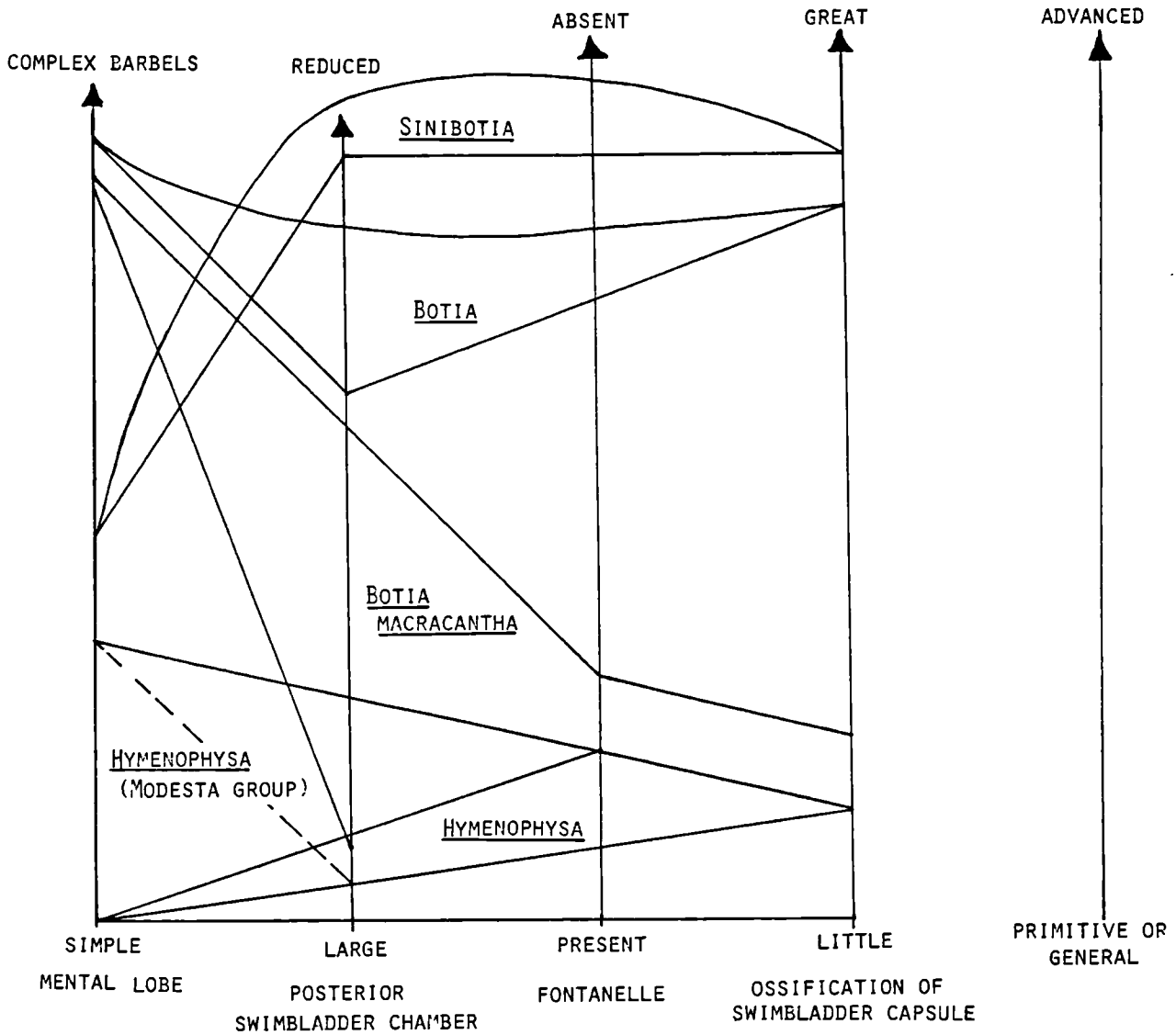

ABSENT
GREAT
ADVANCED
COMPLEX BARBELS
REDUCED
SINIBOTIA
BOTIA
BOTIA
MACRACANTHA
HYMENOPHYSA
(MODESTA GROUP)
HYMENOPHYSA
SIMPLE
LARGE
PRESENT
LITTLE
MENTAL LOBE
POSTERIOR
SWIMBLADDER CHAMBER
FONTANELLE
OSSIFICATION OF
SWIMBLADDER CAPSULE
PRIMITIVE OR
GENERAL

Fig. xxiii Table summarising the elaboration of *m. rostralis* of Botini

	MRMX	MR	MR'	MR''
LEPTOBOTIA PRATTI		+	+	
LEPTOBOTIA FASCIATA		+	+	
LEPTOBOTIA ELONGATA	?+(P76)	+	+	
BOTIA MACRACANTHA	+	+		
BOTIA ALMORHAE	+	+(S)	+(D)	+(D)
BOTIA GETO	+	+	+	
BOTIA HYMENOPHYSA	+	+(S)	+(S)	+(D)
BOTIA BERDMOREI	+	+(S)	+(S)	+(D)
BOTIA MODESTA	+	+(S)	+(D)	+(D)
BOTIA ROBUSTA	+	+	+	
BOTIA SUPERCILIARIS	+	+	+	

Fig. xxiv Branching diagram showing preliminary interpretation of the relationships of the Botini based on characters of the adductor mandibulae and related structures.

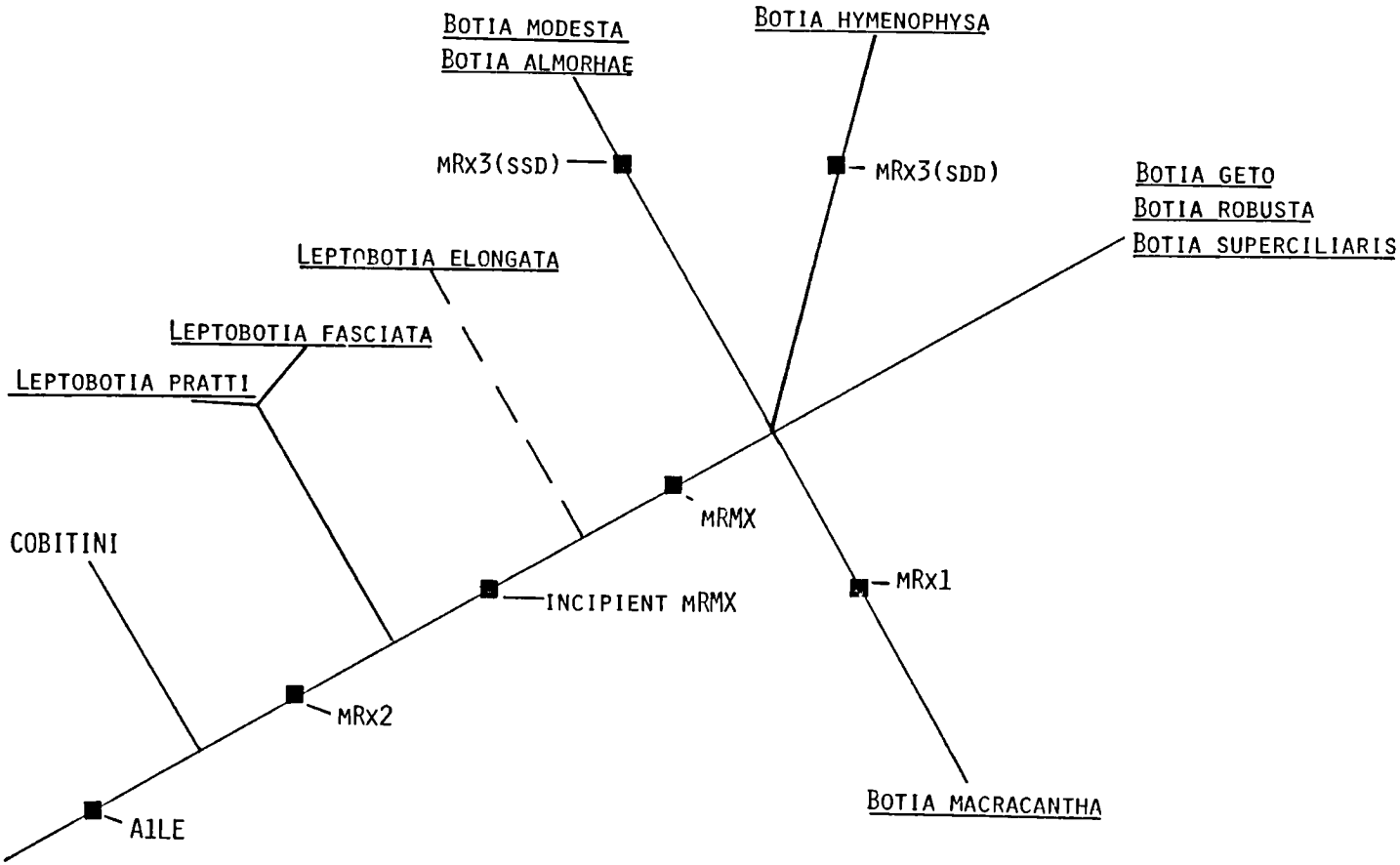

BOTIA MODESTA
BOTIA ALMORHAE
BOTIA HYMENOPHYSA
MRx3(SSD)
MRx3(SDD)
BOTIA GETO
BOTIA ROBUSTA
BOTIA SUPERCILIARIS
LEPTOBOTIA ELONGATA
LEPTOBOTIA FASCIATA
LEPTOBOTIA PRATTI
MRMX
COBITINI
INCIPIENT MRMX
MRx1
MRx2
BOTIA MACRACANTHA
A1LE

Fig. xxv Scheme for the relationships of the Botini and the Cobitini proposed by Nalbant [1963]

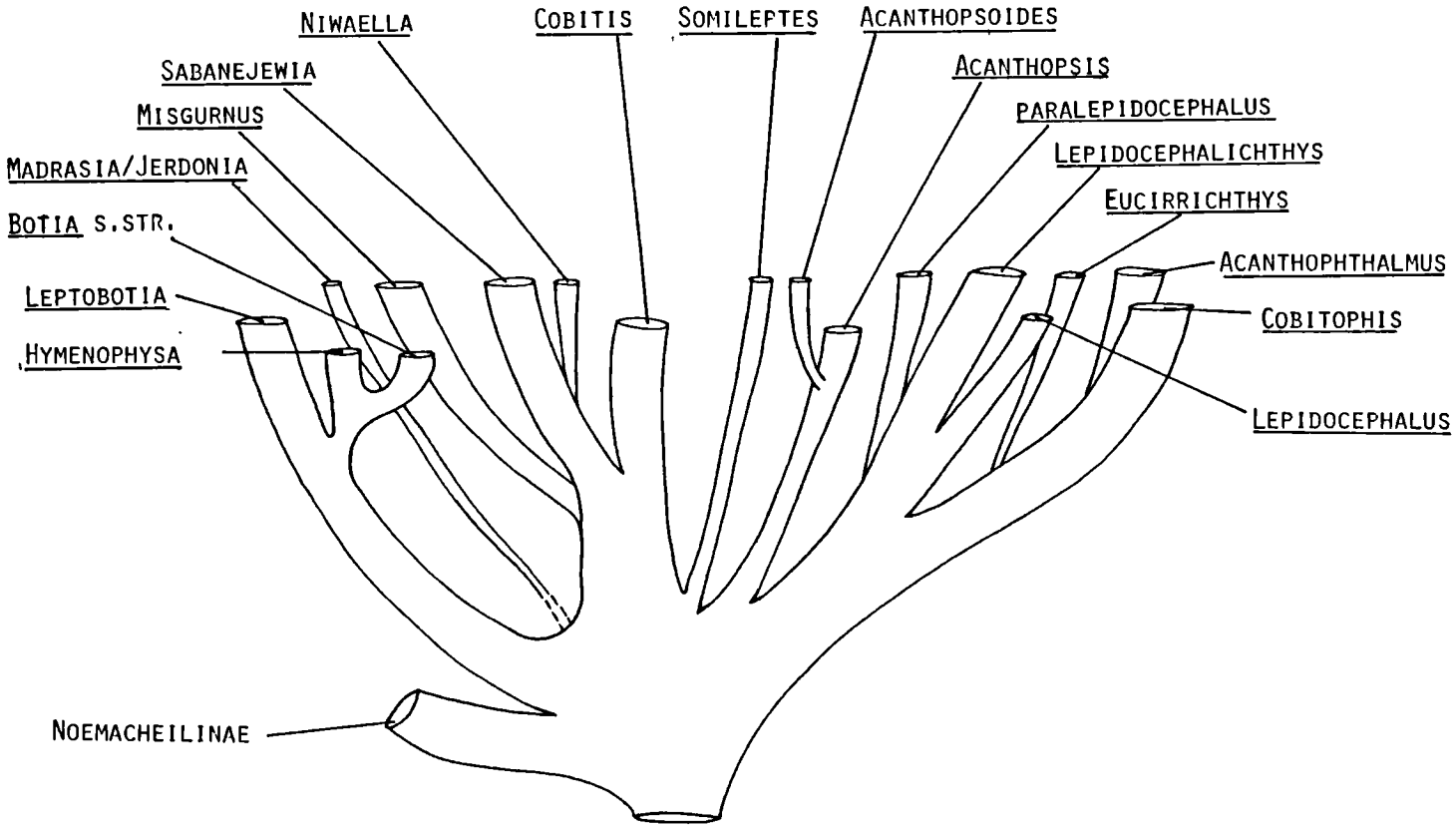

NIWAELLA
COBITIS
SOMILEPTES
ACANTHOPSOIDES
SABANEJEWIA
ACANTHOPSIS
MISGURNUS
PARALEPIDOCEPHALUS
MADRASIA/JERDONIA
LEPIDOCEPHALICHTHYS
BOTIA S.STR.
EUCIRRICHTHYS
LEPTOBOTIA
ACANTHOPHTHALMUS
HYMENOPHYSA
COBITOPHIS
LEPIDOCEPHALUS
NOEMACHEILINAE

Fig. xxvi Branching diagram showing the hypothesis of the relationships of cobitoid fishes - based on characters of the adductor mandibulae and related structures, proposed by Lauder (pers. comm.)

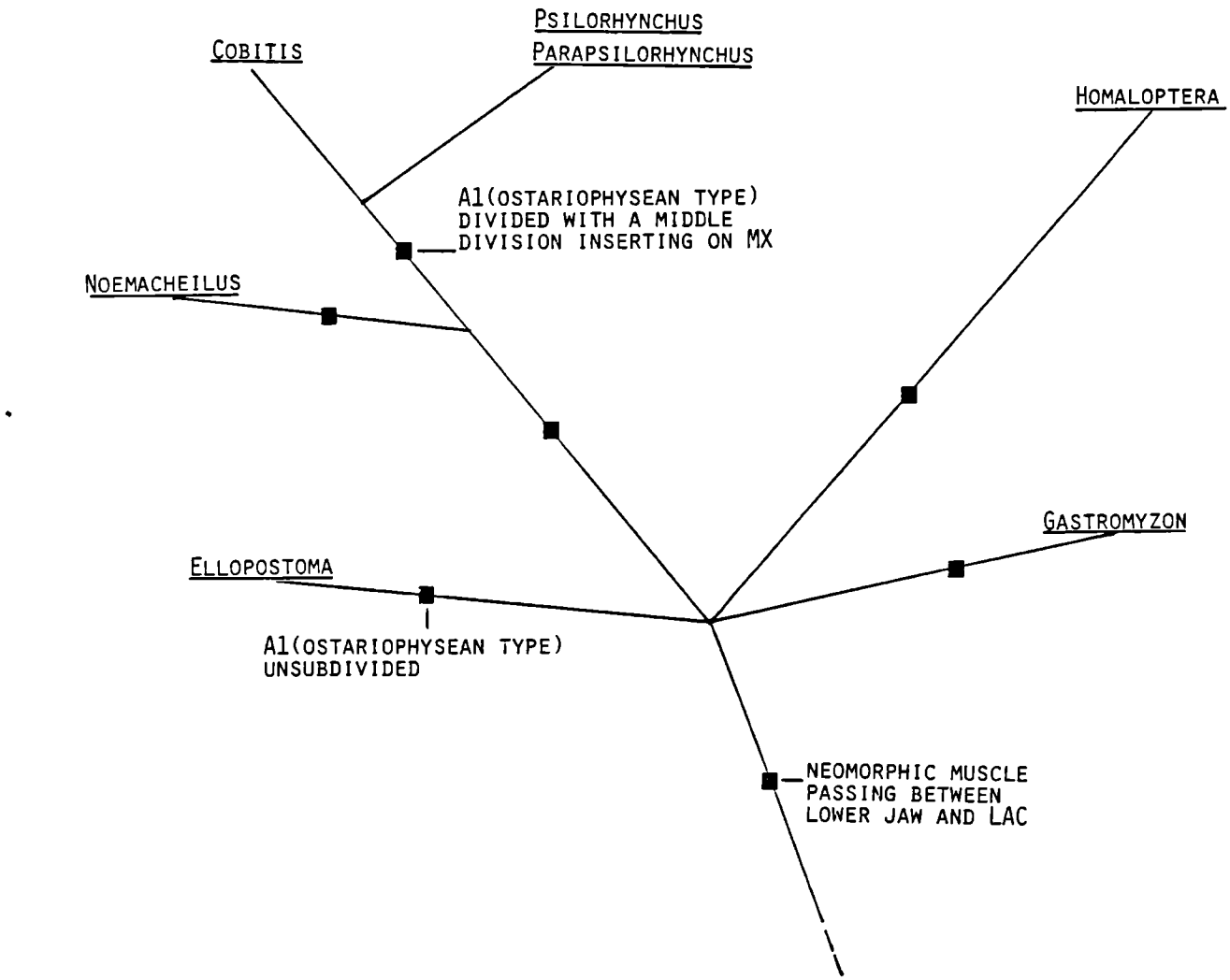
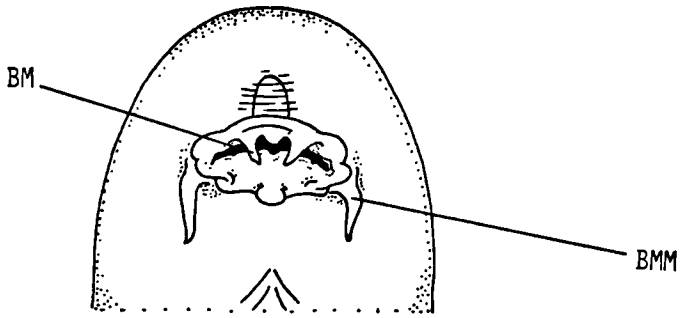

PSILORHYNCHUS
PARAPSILORHYNCHUS
COBITIS
HOMALOPTERA
A1(OSTARIOPHYSEAN TYPE)
DIVIDED WITH A MIDDLE
DIVISION INSERTING ON MX
NOEMACHEILUS
GASTROMYZON
ELLOPOSTOMA
A1(OSTARIOPHYSEAN TYPE)
UNSUBDIVIDED
NEOMORPHIC MUSCLE
PASSING BETWEEN
LOWER JAW AND LAC

Fig. xxvii External oral features (Ventral view)

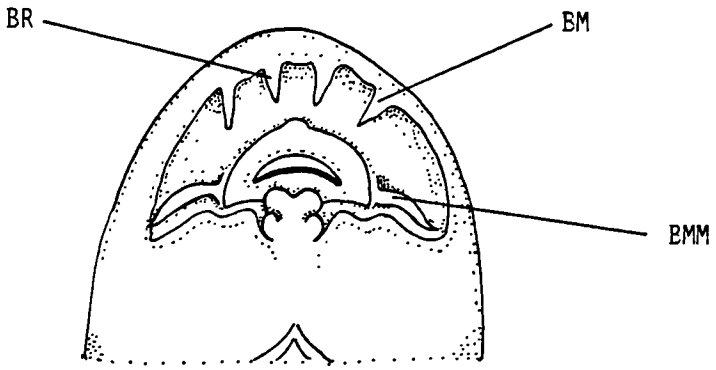
a. Ellopostoma megalomycter

b. Bhavania australis (from Hora & Law, 1942)

a



b



4mm

Fig. xxviii Ethmoid osteology of Ellopostoma

a. left lateral view

b. anterior view

c. dorsal view

d. ventral view

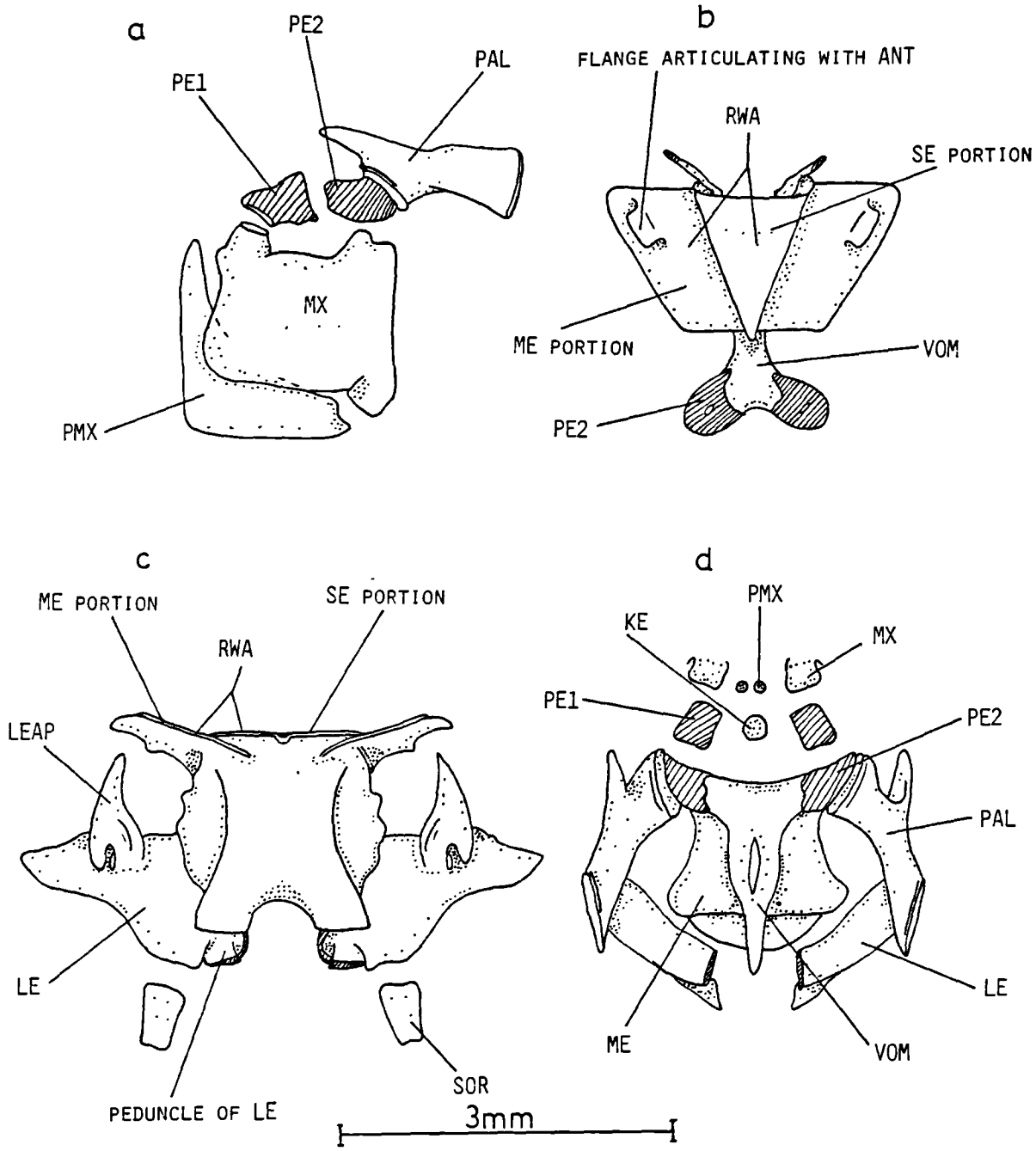

a
PE2
PAL
PE1
MX
PMX
b
FLANGE ARTICULATING WITH ANT
RWA
SE PORTION
ME PORTION
VOM
PE2
c
ME PORTION
SE PORTION
RWA
LEAP
LE
PEDUNCLE OF LE
SOR
3mm
d
PMX
KE
MX
PE1
PE2
PAL
LE
ME
VOM

Fig. xxix Braincase osteology of Ellopostoma

a. ventral view

b. anterior view of posterior orbital wall

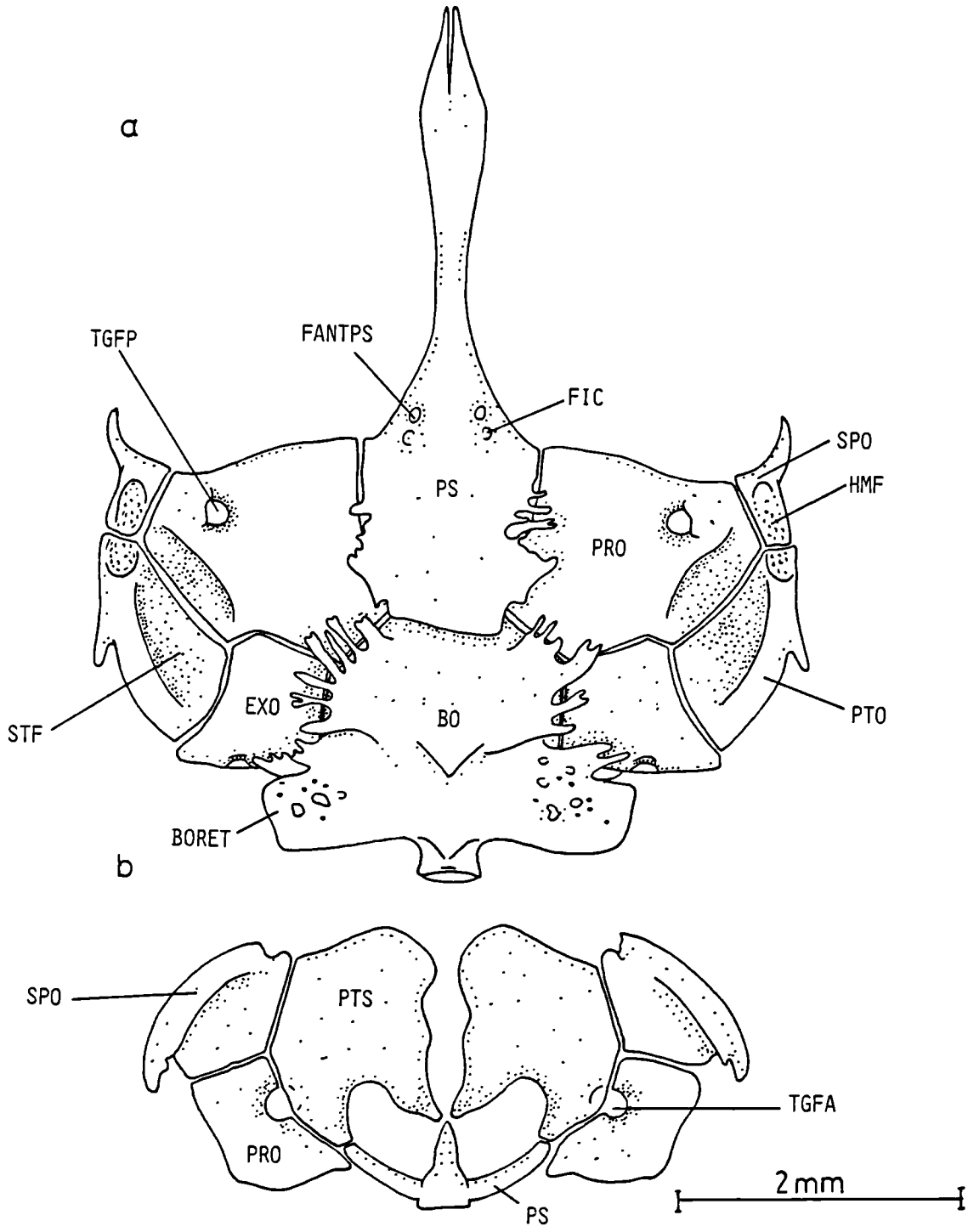

a
TGFP
FANTPS
FIC
SPO
HMF
PS
PRO
EXO
BO
PTO
STF
BORET
b
SPO
PTS
TGFA
PRO
PS
2mm

Fig. xxx Caudal skeleton (Left lateral view)

a. Ellopostoma

b. Noemacheilus botia

c. Parakneria witti

d. juvenile Barilius bendelisis

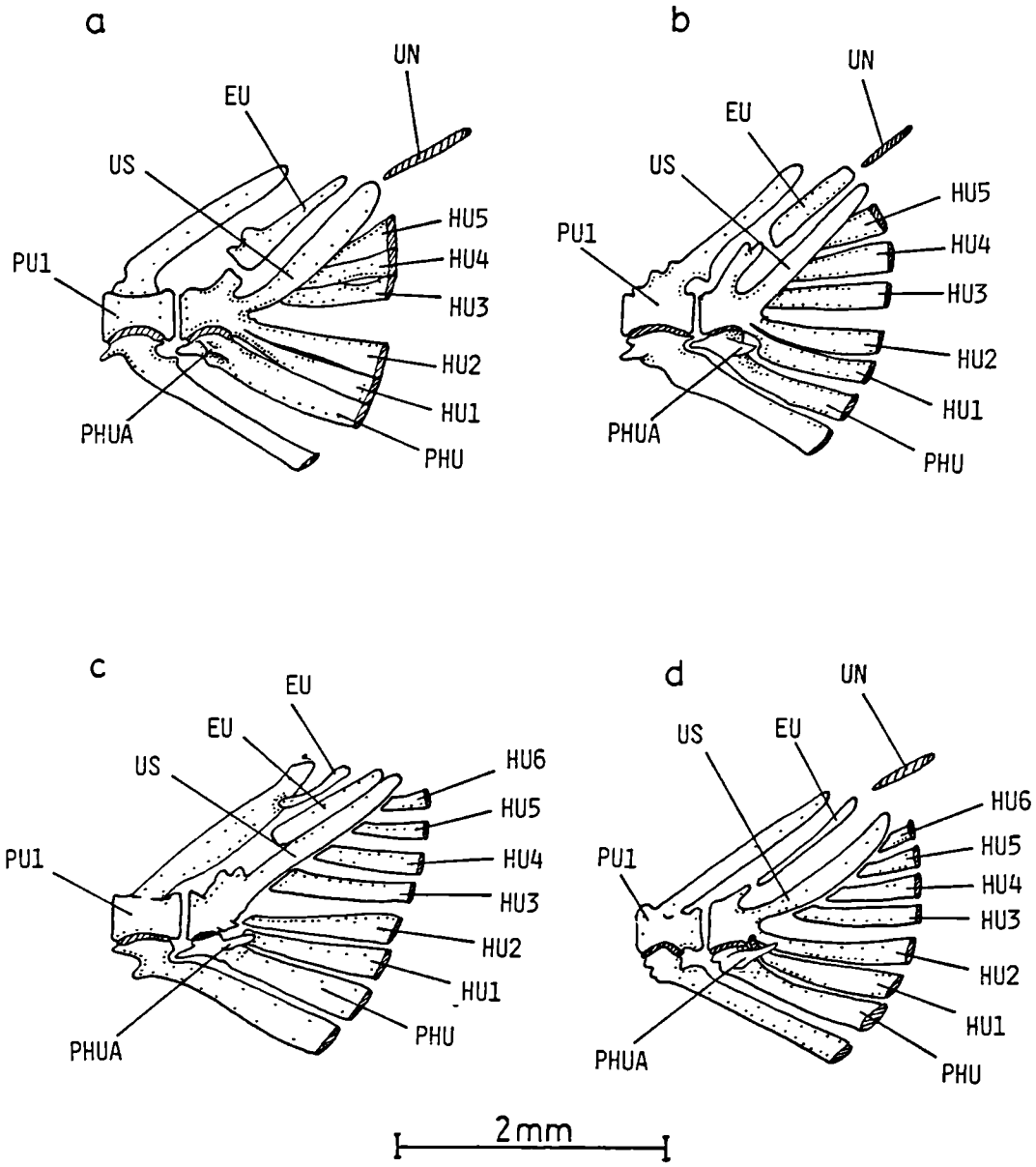

a
UN
EU
US
HU5
PU1
HU4
HU3
HU2
HU1
PHUA
PHU
b
UN
EU
US
HU5
PU1
HU4
HU3
HU2
HU1
PHUA
PHU
c
EU
EU
US
HU6
HU5
PU1
HU4
HU3
HU2
HU1
PHUA
PHU
d
UN
US
EU
HU6
HU5
PU1
HU4
HU3
HU2
HU1
PHUA
PHU
2mm

Fig. xxxi Ossification associated with V1-4 in *Ellopostoma*

a. Left lateral view

b. Ventral view

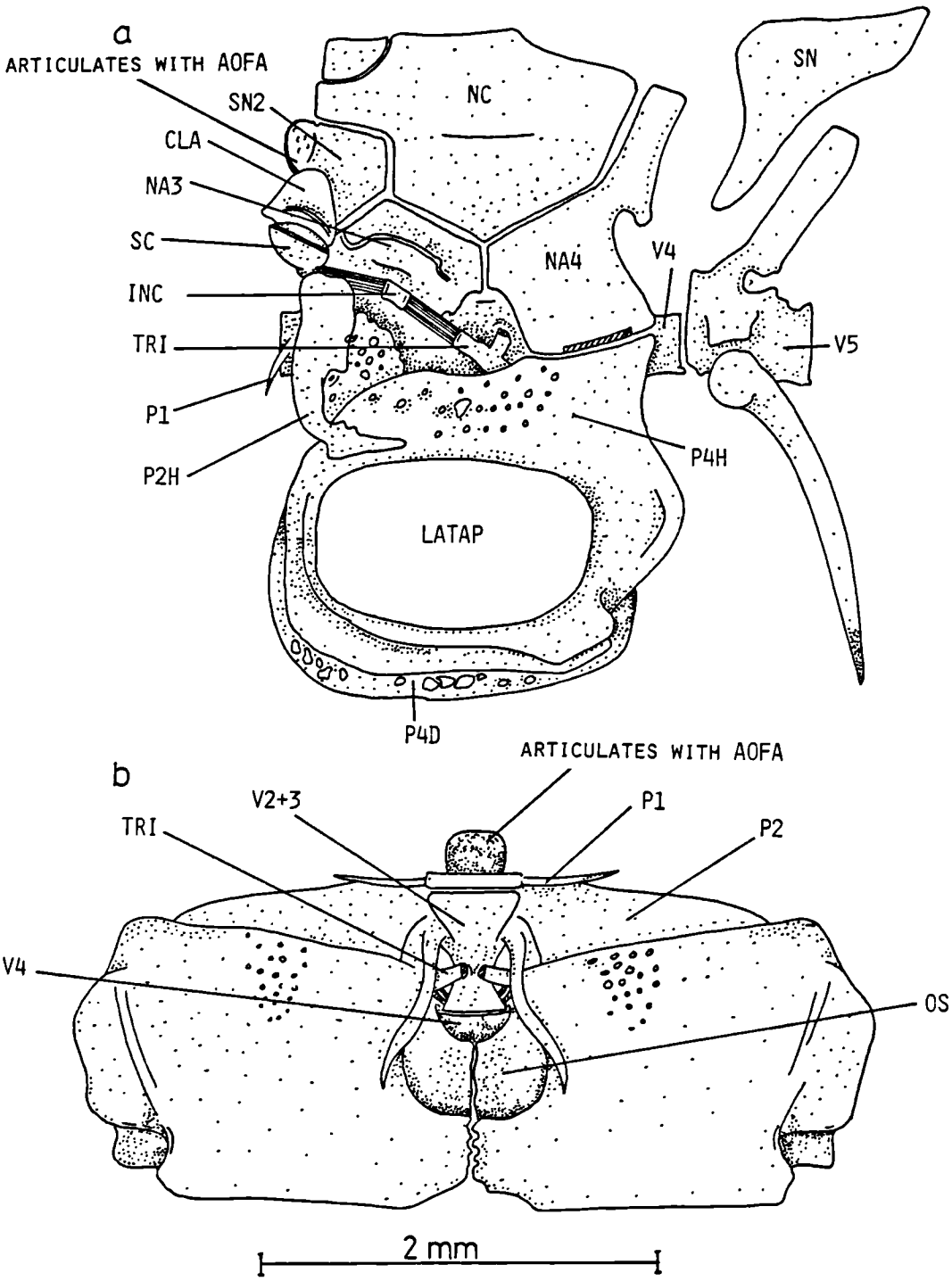

a
ARTICULATES WITH AOFA
SN2
CLA
NA3
SC
INC
TRI
P1
P2H
NC
NA4
V4
SN
V5
P4H
LATAP
P4D
b
ARTICULATES WITH AOFA
V2+3
TRI
P1
P2
V4
OS
2 mm

Fig. xxxii External oral features (Ventral view)

a. Vaillantella flavofasciata

b. Noemacheilus poonensis

c. Noemacheilus pulcher

d. Noemacheilus corica

e. Botia hymenophysa

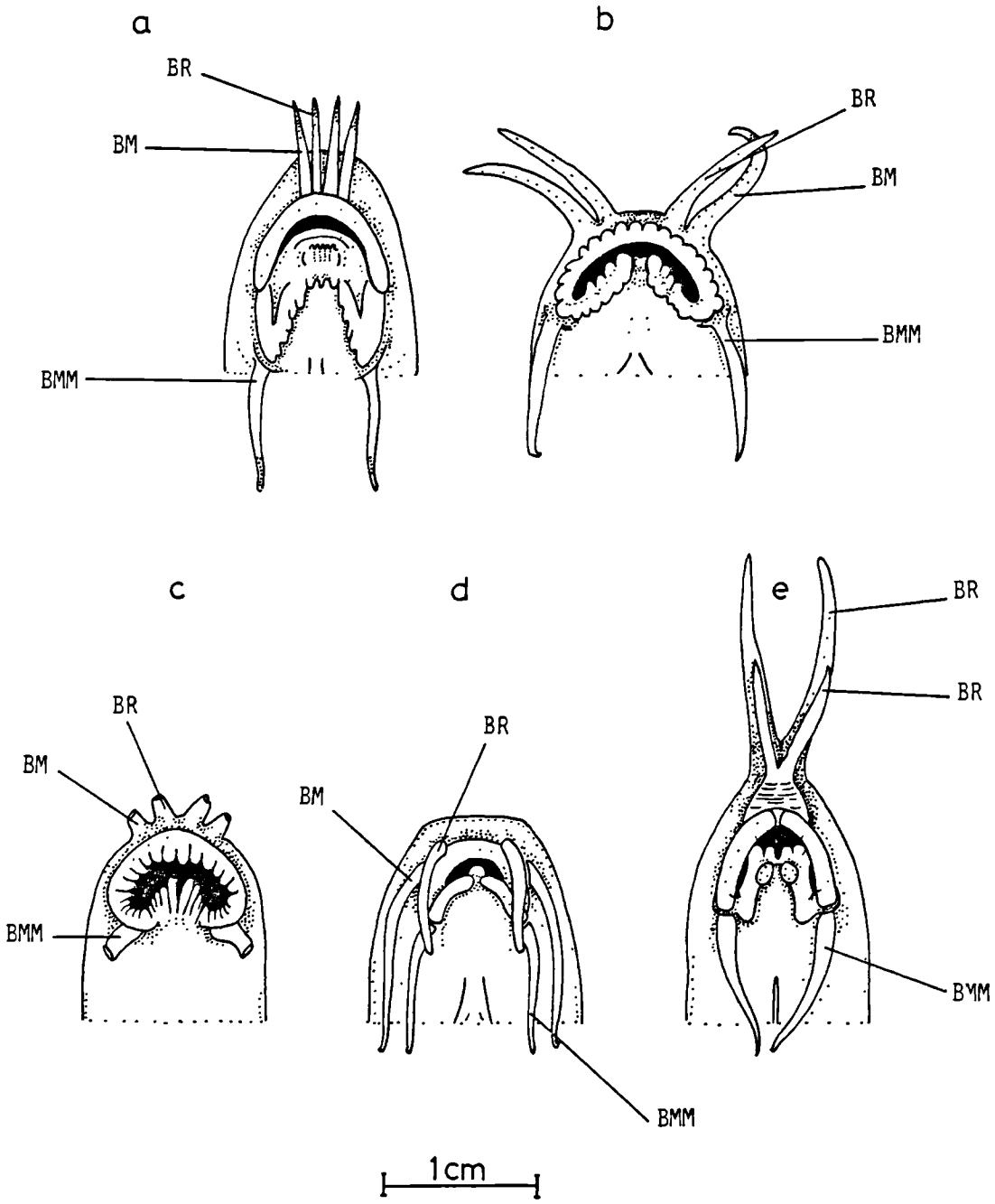

a
BR
BM
BMM
b
BR
BM
BMM
c
BR
BM
BMM
d
BR
BM
BMM
e
BR
BR
BMM
1cm

Fig. xxxiii Skull of Vaillantella

(Ventral view)

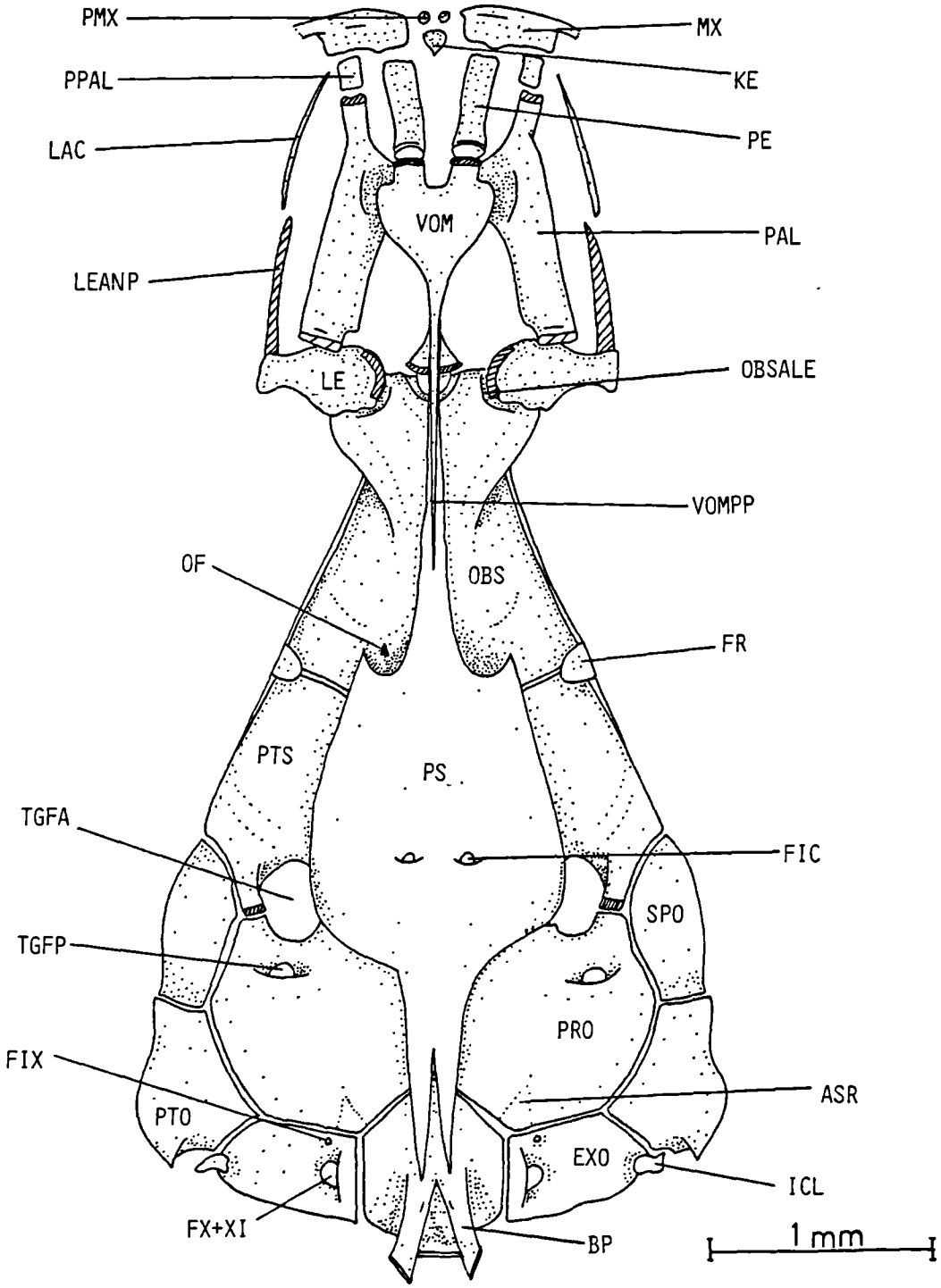

PMX
MX
PPAL
KE
LAC
PE
VOM
PAL
LEANP
LE
OBSALE
VOMPP
OF
OBS
FR
PTS
PS
TGFA
FIC
SPO
TGFP
PRO
FIX
ASR
PTO
EXO
ICL
FX+XI
BP
1 mm

Fig.xxxiv a. Pelvic skeleton of Vaillantella
(Dorsal view)
b. Caudal skeleton of Vaillantella
(Left lateral view)

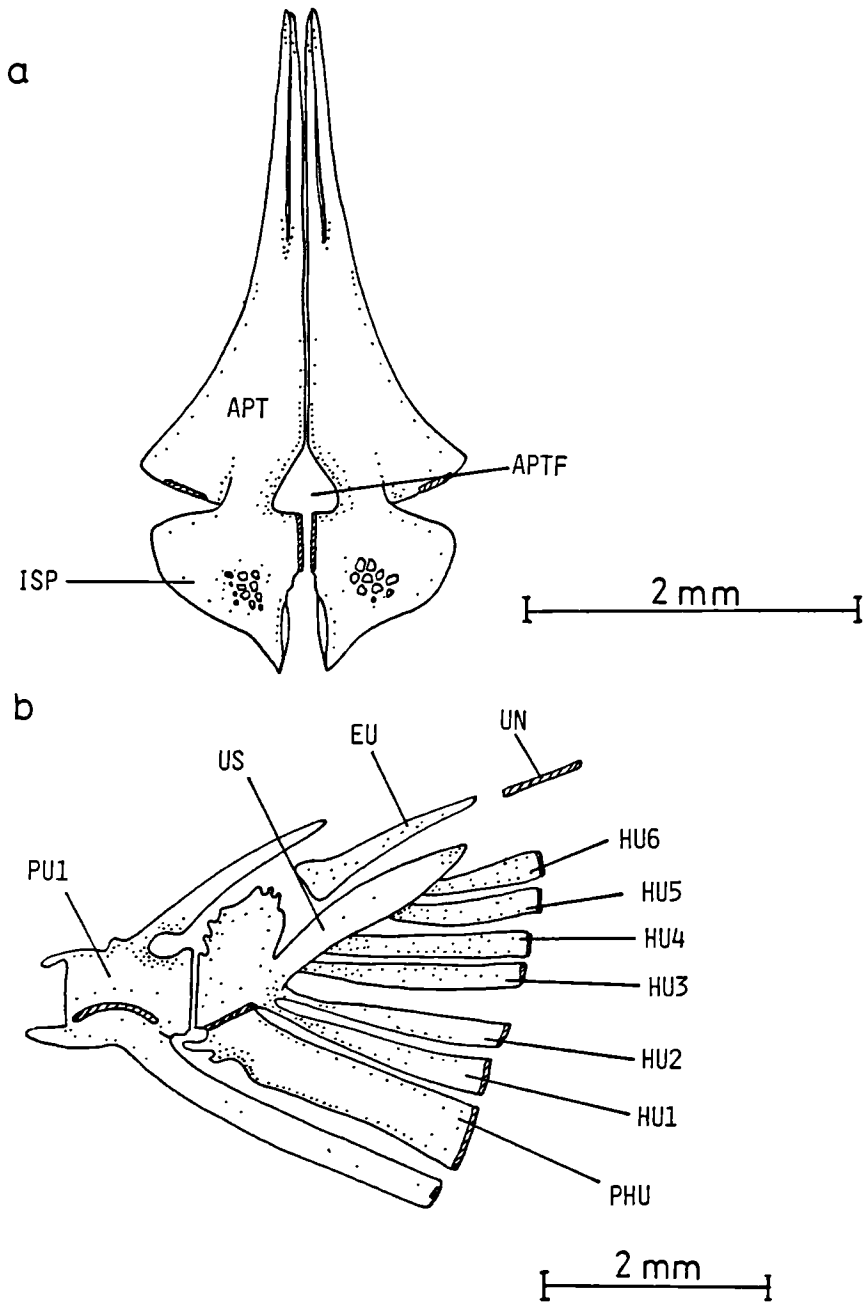

a
APT
APTF
ISP
2 mm
b
UN
EU
US
PU1
HU6
HU5
HU4
HU3
HU2
HU1
PHU
2 mm

Fig. xxxv Ossification associated with V1-4 in *Vaillantella*

a. Left lateral view

b. Ventral view

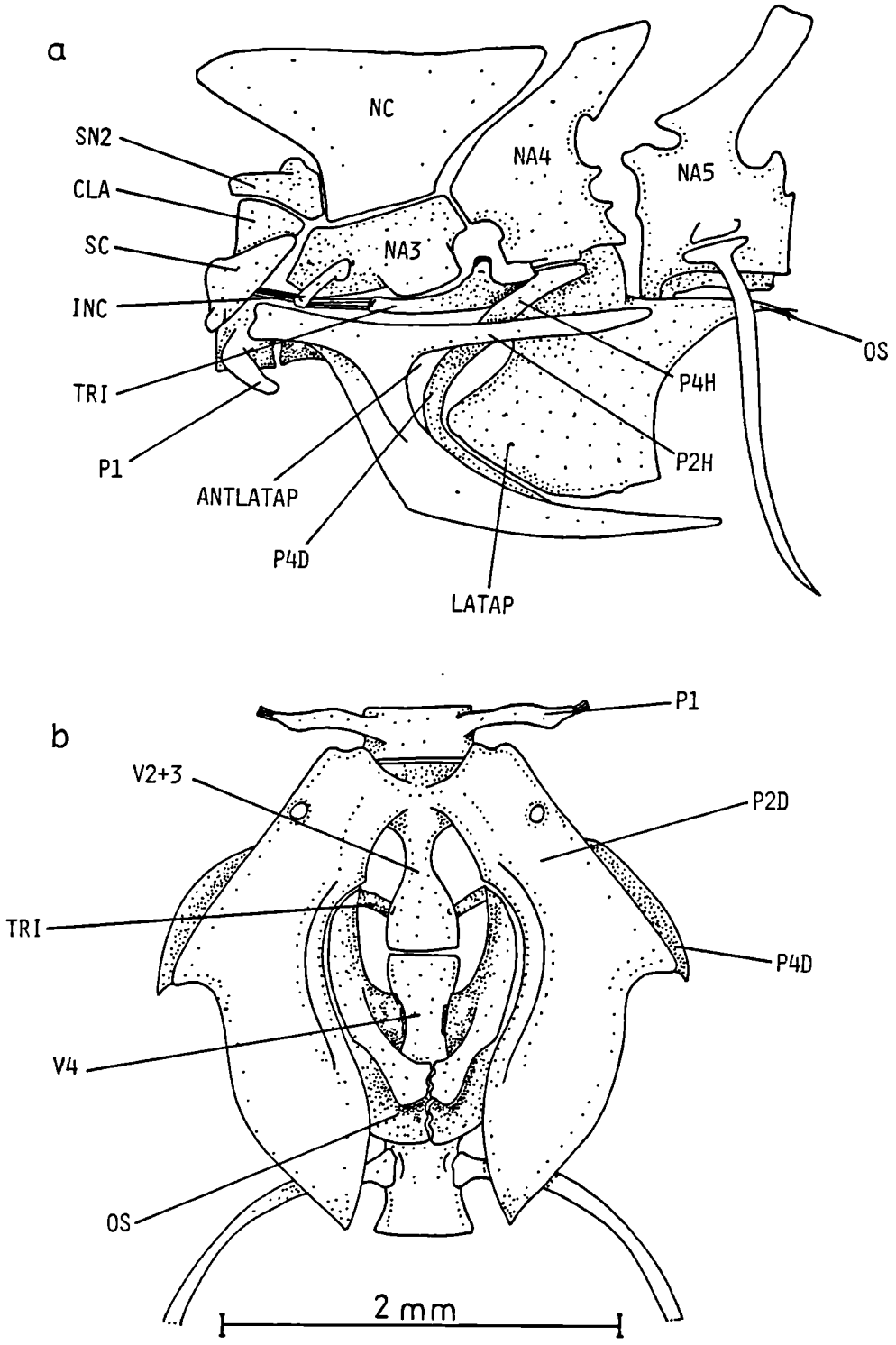

a
NC
SN2
CLA
SC
INC
TRI
P1
ANTLATAP
P4D
LATAP
NA3
NA4
NA5
P4H
P2H
OS
b
P1
V2+3
P2D
TRI
P4D
V4
OS
2 mm

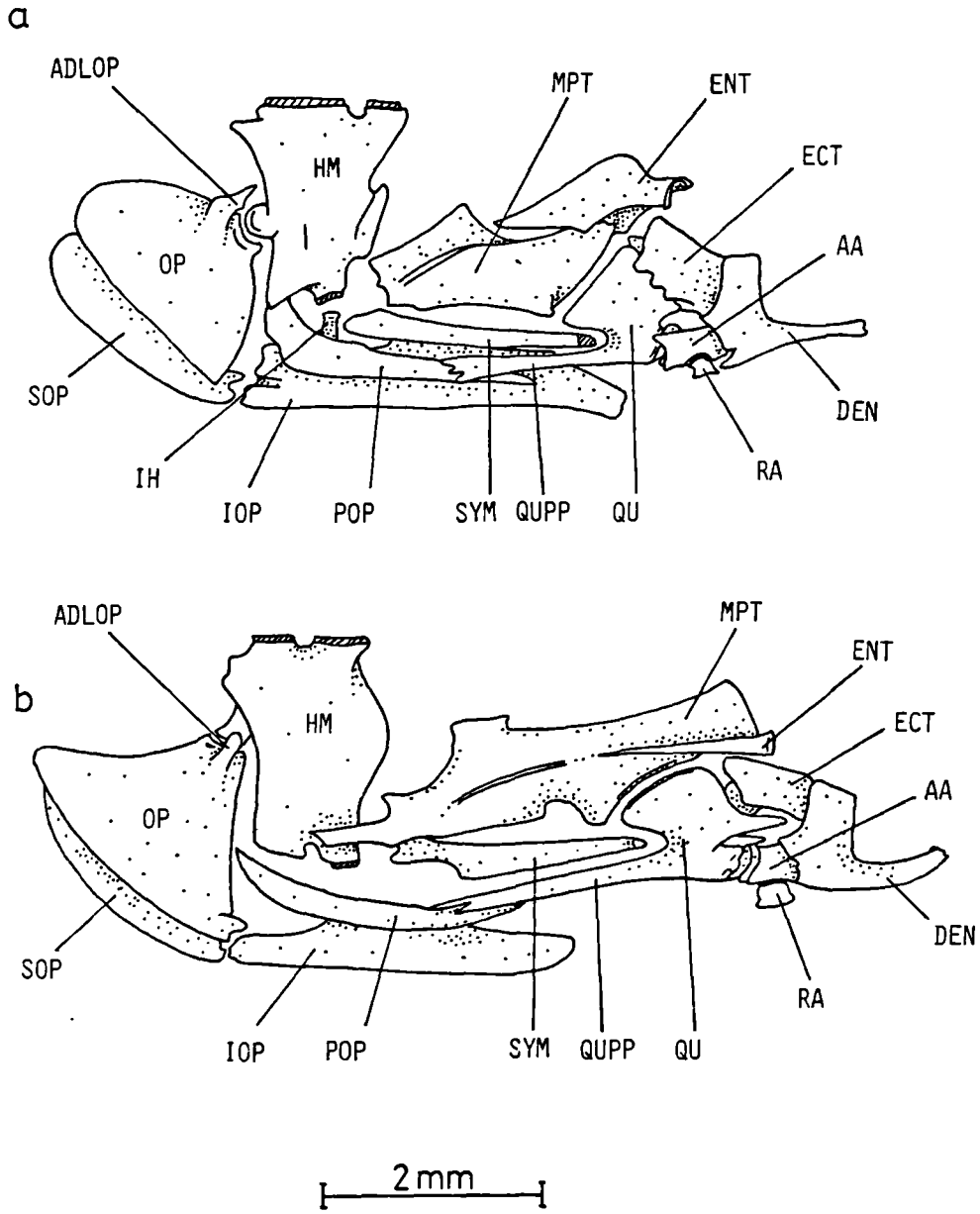
Fig. xxxvi Suspensorium and opercular series in noemacheilids (Right lateral view)

a. Oronectes platycephalus

b. Glaniopsis hanitschi

c. Ellopostoma

d. Vaillantella


a
ADLOP
MPT
ENT
HM
ECT
AA
OP
SOP
DEN
IH
RA
IOP
POP
SYM
QUPP
QU
b
ADLOP
MPT
ENT
HM
ECT
AA
OP
SOP
DEN
RA
IOP
POP
SYM
QUPP
QU
2 mm

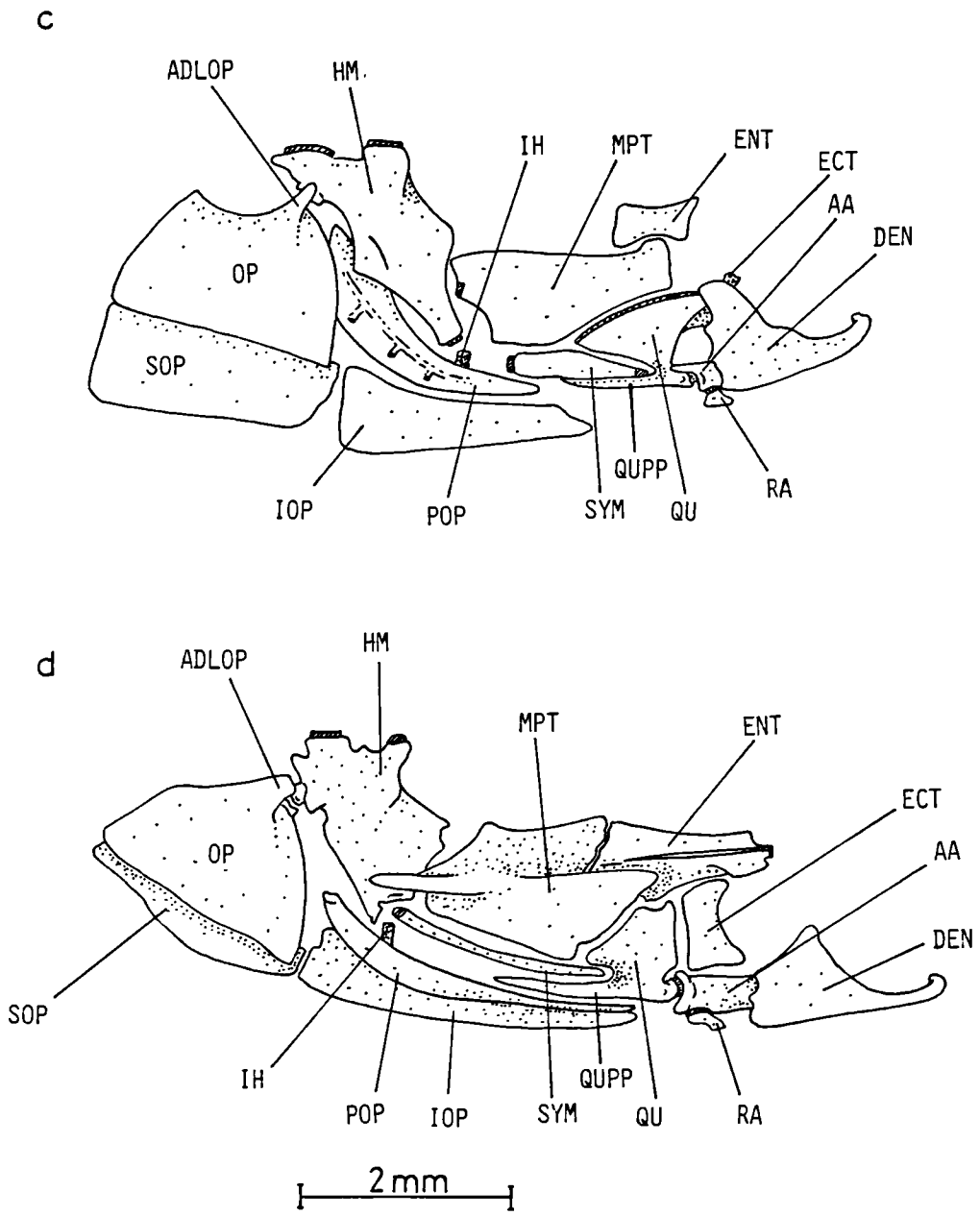

c
ADLOP
HM
IH
MPT
ENT
ECT
AA
DEN
OP
SOP
IOP
POP
SYM
QU
QUPP
RA
d
ADLOP
HM
MPT
ENT
ECT
AA
DEN
OP
SOP
IH
POP
IOP
SYM
QU
QUPP
RA
2 mm

Fig. xxxvii Hyomandibula (Right lateral view)

a. Botia macracantha

b. Barilius bendelisis

c. Suspensorium and opercular series

Botia modesta (Right lateral view

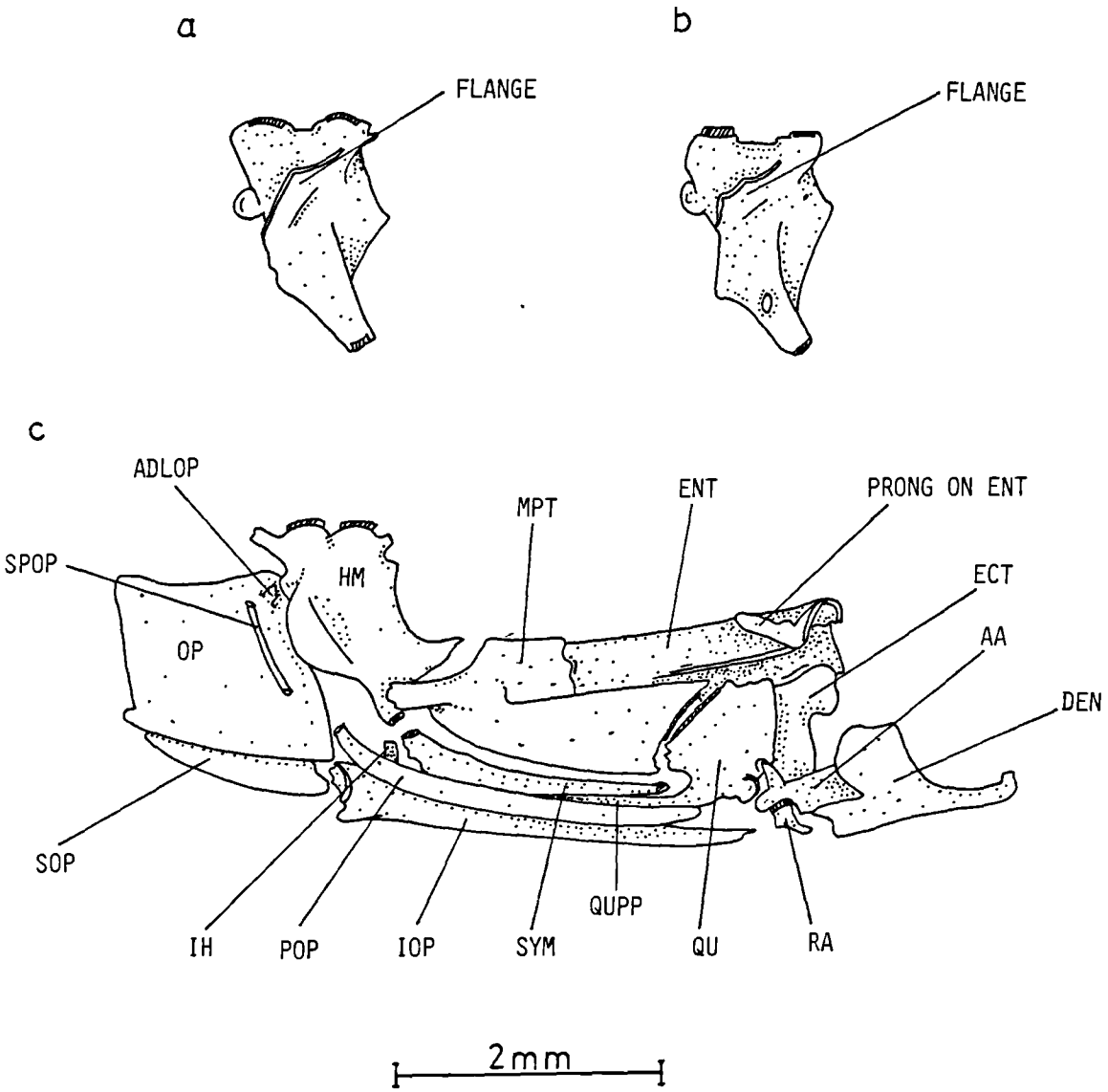

a
FLANGE
b
FLANGE
c
ADLOP
SPOP
OP
HM
MPT
ENT
PRONG ON ENT
ECT
AA
DEN
SOP
IH
POP
IOP
SYM
QUPP
QU
RA
2mm

Fig. xxxviii Lower jaw osteology (Left medial view)

a. Noemacheilus montanus

b. Lefua nikkonis

c. Ellopostoma

d. Vaillantella

e. Acanthopsis choirorhynchus

f. Lepidocephalus caudofurcatus

g. Lepidocephalus annandali

h. Botia berdmorei

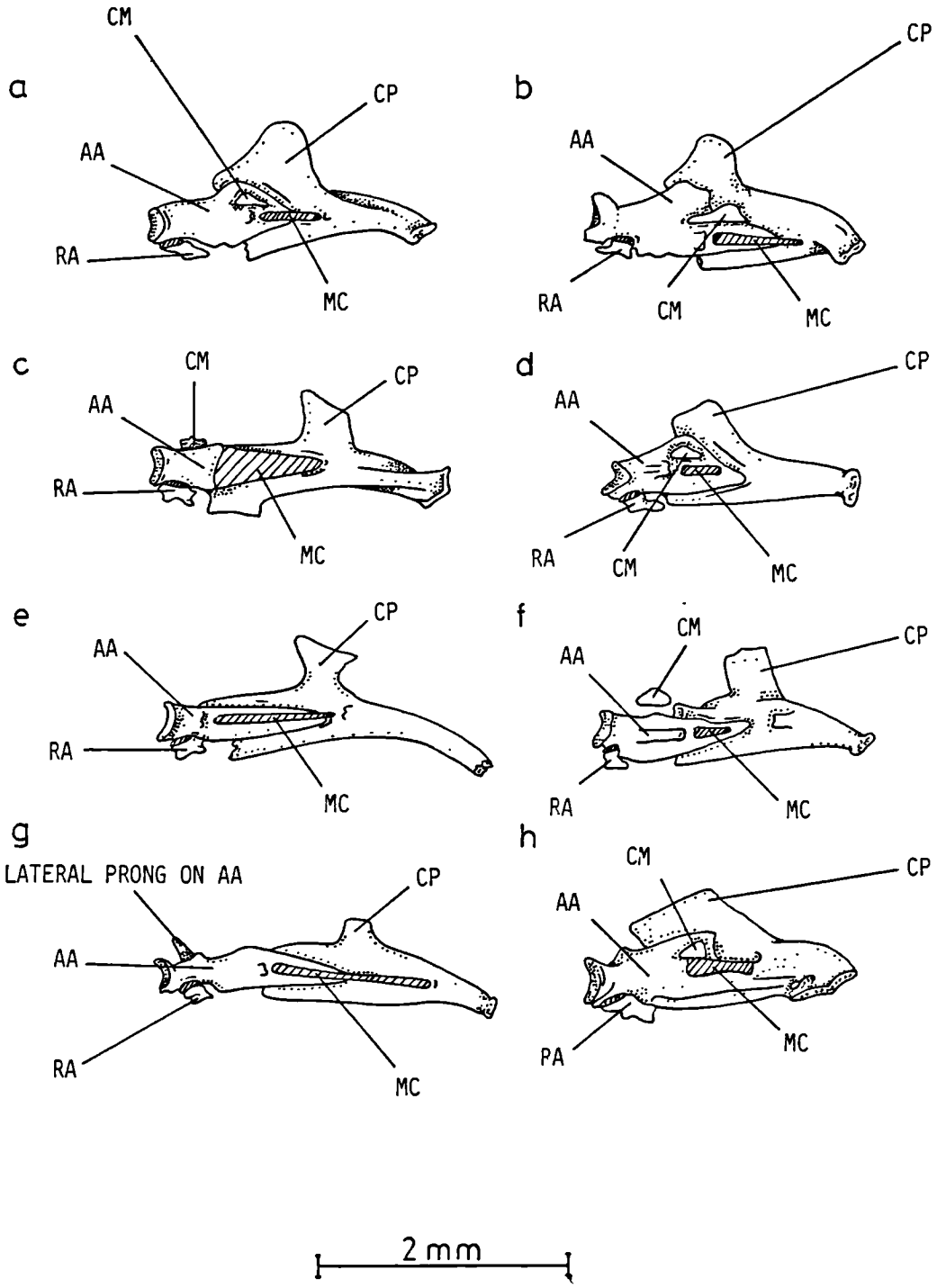

a
CM
CP
AA
RA
MC
b
CP
AA
RA
CM
MC
c
CM
CP
AA
RA
MC
d
CP
AA
RA
CM
MC
e
CP
AA
RA
MC
f
CM
CP
AA
RA
MC
g
LATERAL PRONG ON AA
CP
AA
RA
MC
h
CM
CP
AA
PA
MC
2 mm

Fig. xxxix Upper jaw osteology (Right lateral view)

a. Noemacheilus strauchi

b. Noemacheilus rupecola

c. Vaillantella

d. Ellopostoma

e. Niwaella delicta

f. Acanthopsis choirorhynchus

g. Botia berdmorei

h. Gyrinocheilus aymonieri

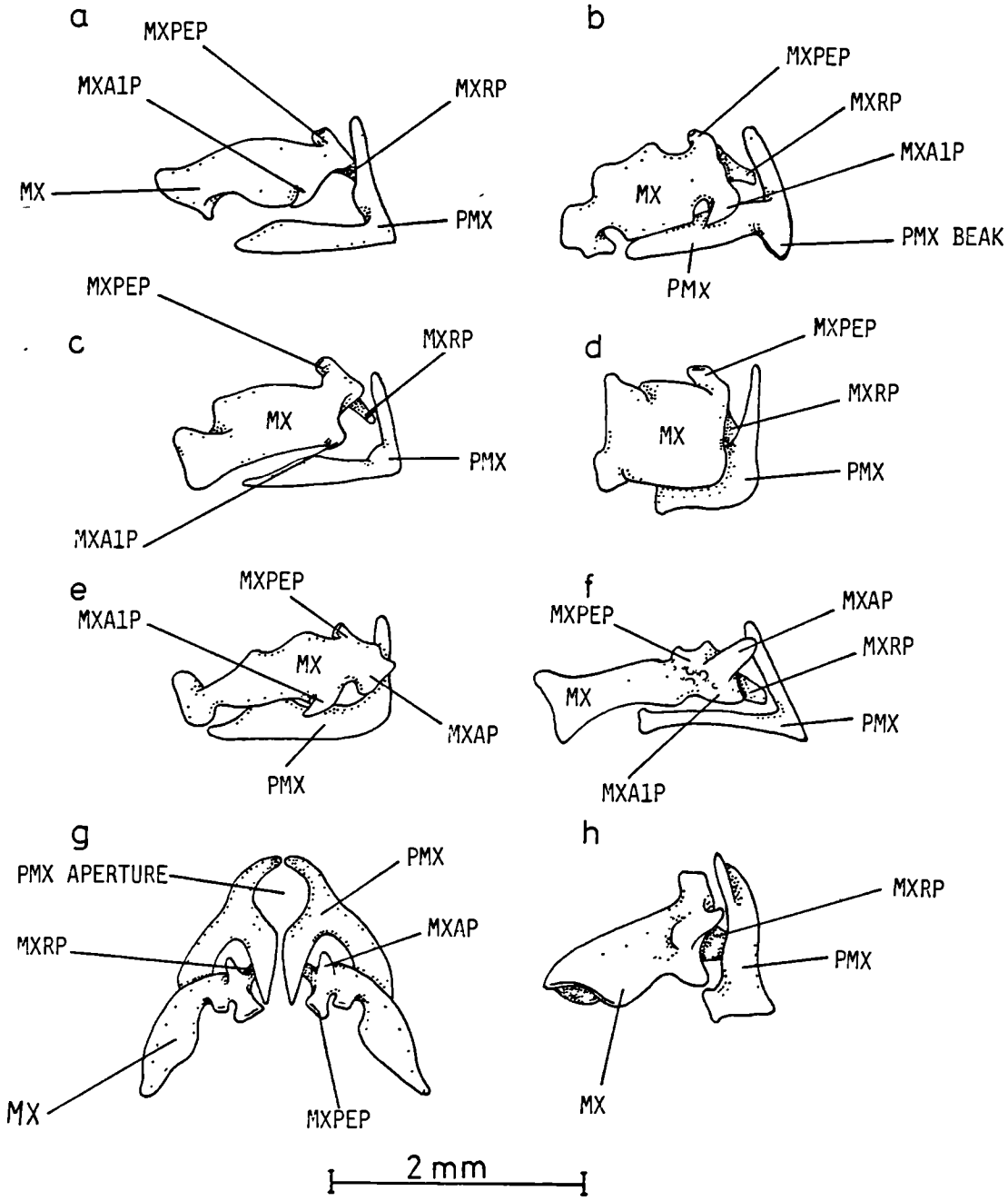

a
MXPEP
MXA1P
MXRP
MX
PMX
b
MXPEP
MXRP
MXA1P
MX
PMX BEAK
PMX
c
MXPEP
MXRP
MX
PMX
MXA1P
d
MXPEP
MXRP
MX
PMX
e
MXPEP
MXA1P
MX
MXAP
PMX
f
MXAP
MXPEP
MXRP
MX
PMX
MXA1P
g
PMX APERTURE
PMX
MXAP
MXRP
MX
MXPEP
h
MXRP
PMX
MX
2 mm

Fig. xL Kinethmoid bone (Posterior view)

a. Noemacheilus fasciatus

b. Noemacheilus denisoni

c. Oronectes platycephalus

d. Noemacheilus nigromaculatus

e. Glaniopsis hanitschi

f. Misgurnus anguillicaudatus

g. Acanthophthalmus semicinctus

h. Acanthopsis choirorhynchus

i. Leptobotia fasciata

j. Botia sidthimunki

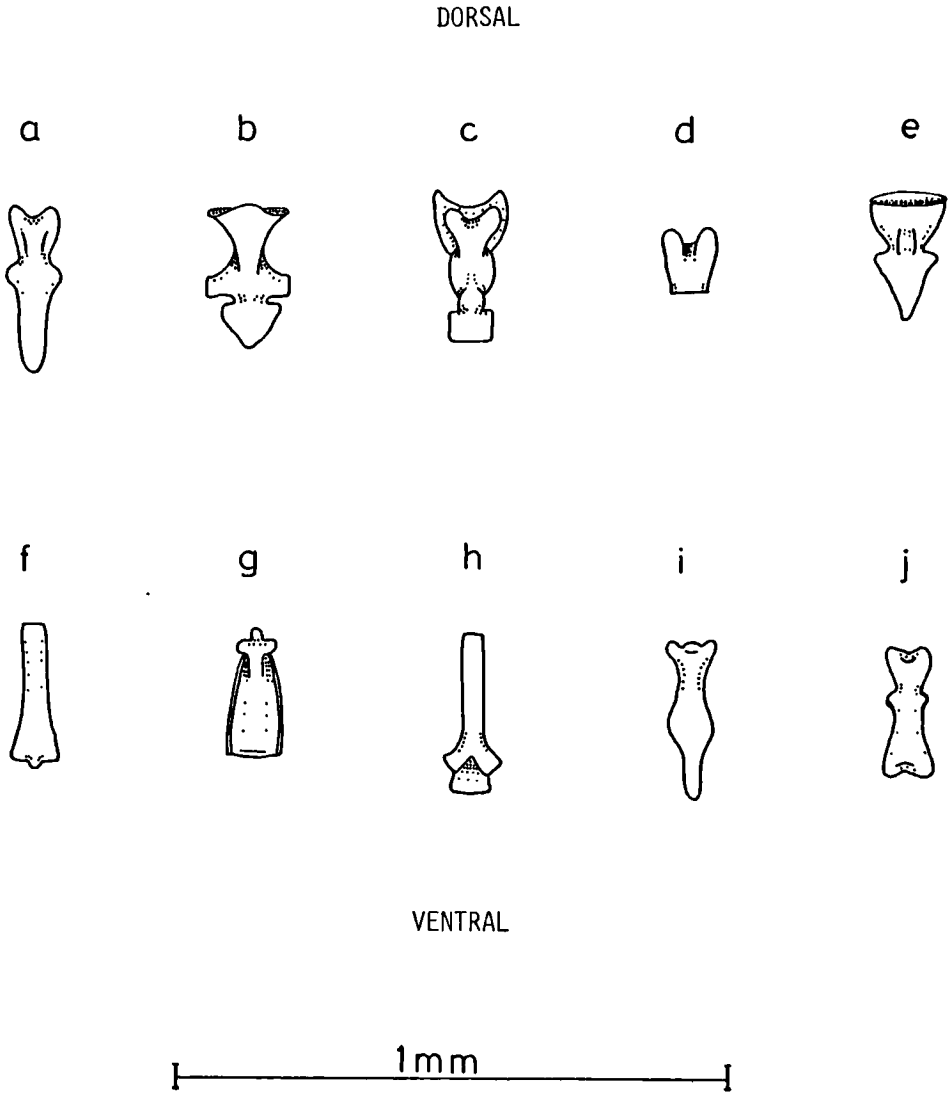

DORSAL
a
b
c
d
e
f
g
h
i
j
VENTRAL
1mm

Fig. xLi Ethmoid osteology (Ventral view)

a. Sternopygus macurus (from De la Hoz and Chardon 1975)

b. Hypopygus lepturnus

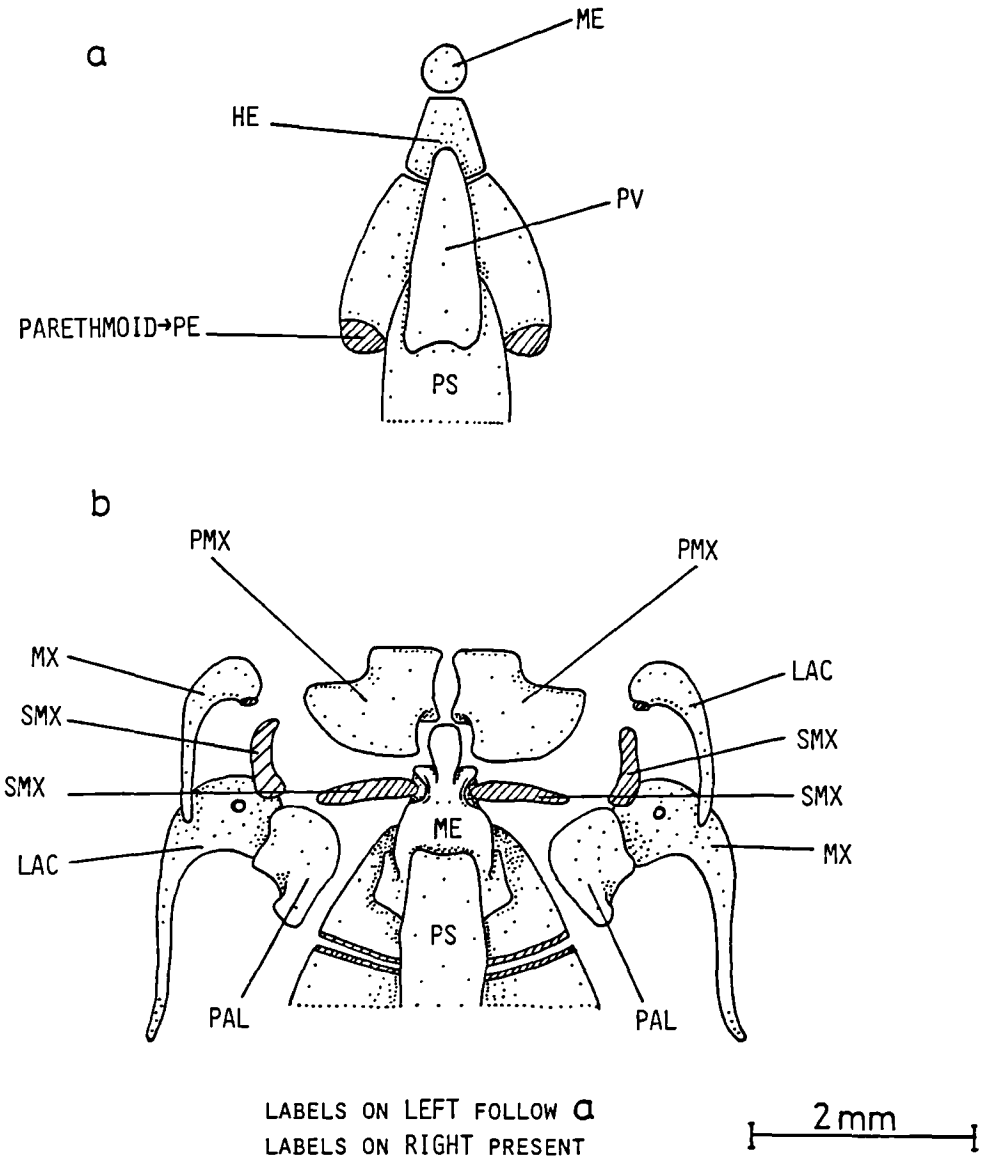

a
ME
HE
PV
PARETHMOID→PE
PS
b
PMX
PMX
MX
SMX
SMX
LAC
LAC
SMX
SMX
ME
MX
PS
PAL
PAL
LABELS ON LEFT FOLLOW a
LABELS ON RIGHT PRESENT
ALTERNATIVE INTERPRETATION
2 mm

Fig. xLii Table showing distribution of preethmoid ossifications amongst the noemacheilids

	PE1	PE2	PPAL	SES
NOEMACHEILUS FASCIATUS	+ +	+	+	
NOEMACHEILUS BARBATULUS	+	+	+	
NOEMACHEILUS BOTIA	+		+	+
NOEMACHEILUS CORICA	+		+	
NOEMACHEILUS DENISONII	+		+	
NOEMACHEILUS MONTANUS	+		+	+
NOEMACHEILUS NIGROMACULATUS	+		+	
NOEMACHEILUS RUPECOLA	+		+	+
NOEMACHEILUS STOLICZKAE	+	+	+	
NOEMACHEILUS STRAUCHI	+	+	+	
NOEMACHEILUS YARKANDENSIS	+	+	+	
ABORICHTHYS ELONGATUS	+		+	+
LEFUA NIKKONIS	+	+	+	
ORONECTES PLATYCEPHALUS	+	+	+	
ORTHRIAS TSCHAIYSSUENSIS	+		+	+
VAILLANTELLA	+		+	
ELLOPOSTOMA	+	+		
GLANIOPSIS HANITSCHI	+	+	+	
GASTROMYZON BORNEENSIS	+	+		
HOMALOPTERA ORTHAGONIATA	+		+	

Fig. xLiii Ethmoprevomerine region and preethmoid ossification.

a. Noemacheilus montanus (Ventral view)

b. Noemacheilus strauchi (Ventral view)

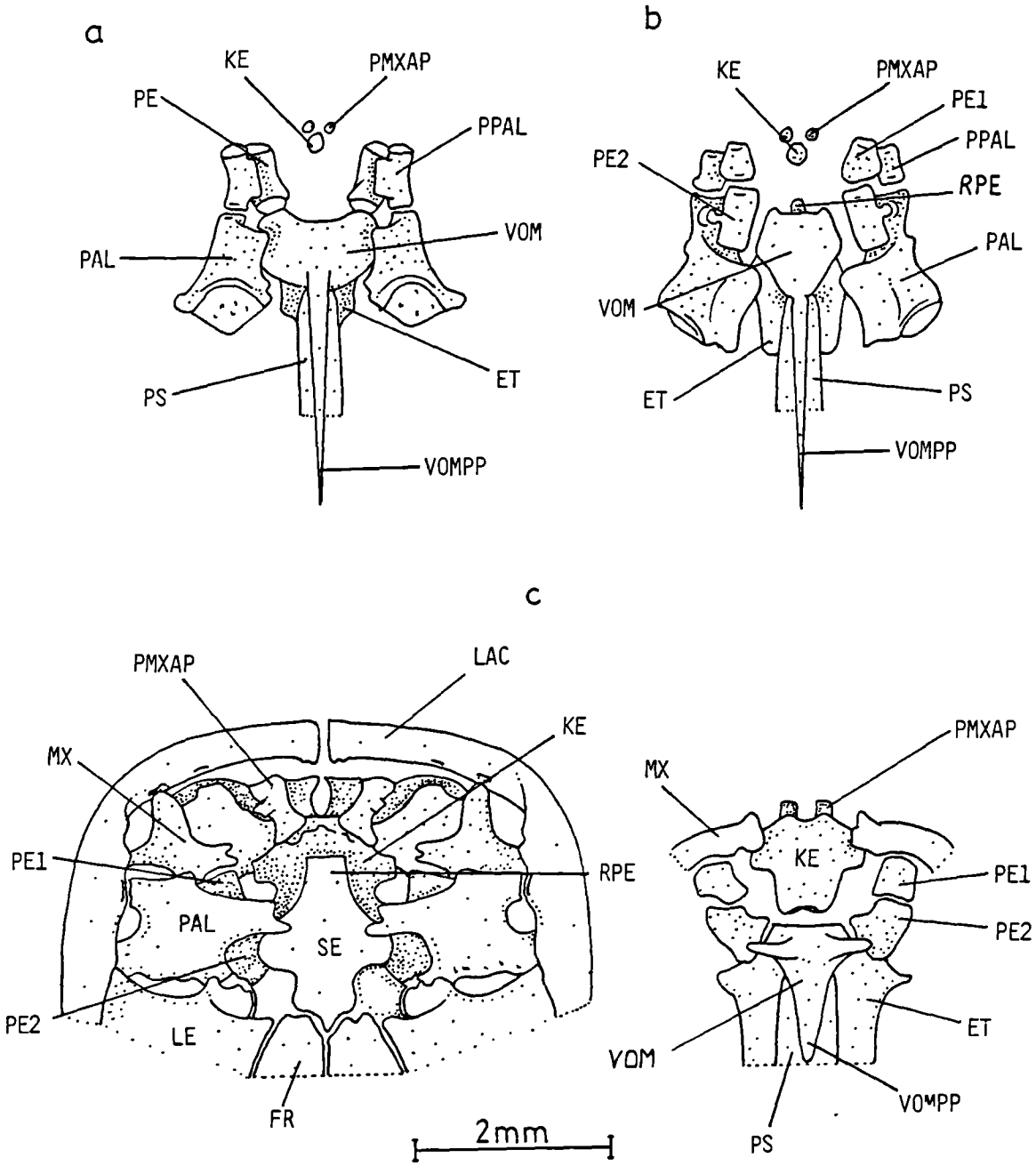
c. Gastromyzon borneensis (Left, dorsal view, right, ventral view)

d. Homaloptera orthongoniata (Dorsal view)

e. Acanthopsis choirorhynchus (Ventral view)

f. Abbottina rivularis (Ventral view)

g. Catostomus catostomus (Ventral view)


a
KE
PMXAP
PE
PPAL
VOM
PAL
ET
PS
VOMPP
b
KE
PMXAP
PE1
PPAL
PE2
RPE
PAL
VOM
ET
PS
VOMPP
c
PMXAP
LAC
KE
MX
PE1
RPE
PAL
SE
PE2
LE
FR
2mm
PMXAP
MX
KE
PE1
PE2
ET
VOM
VOMPP
PS

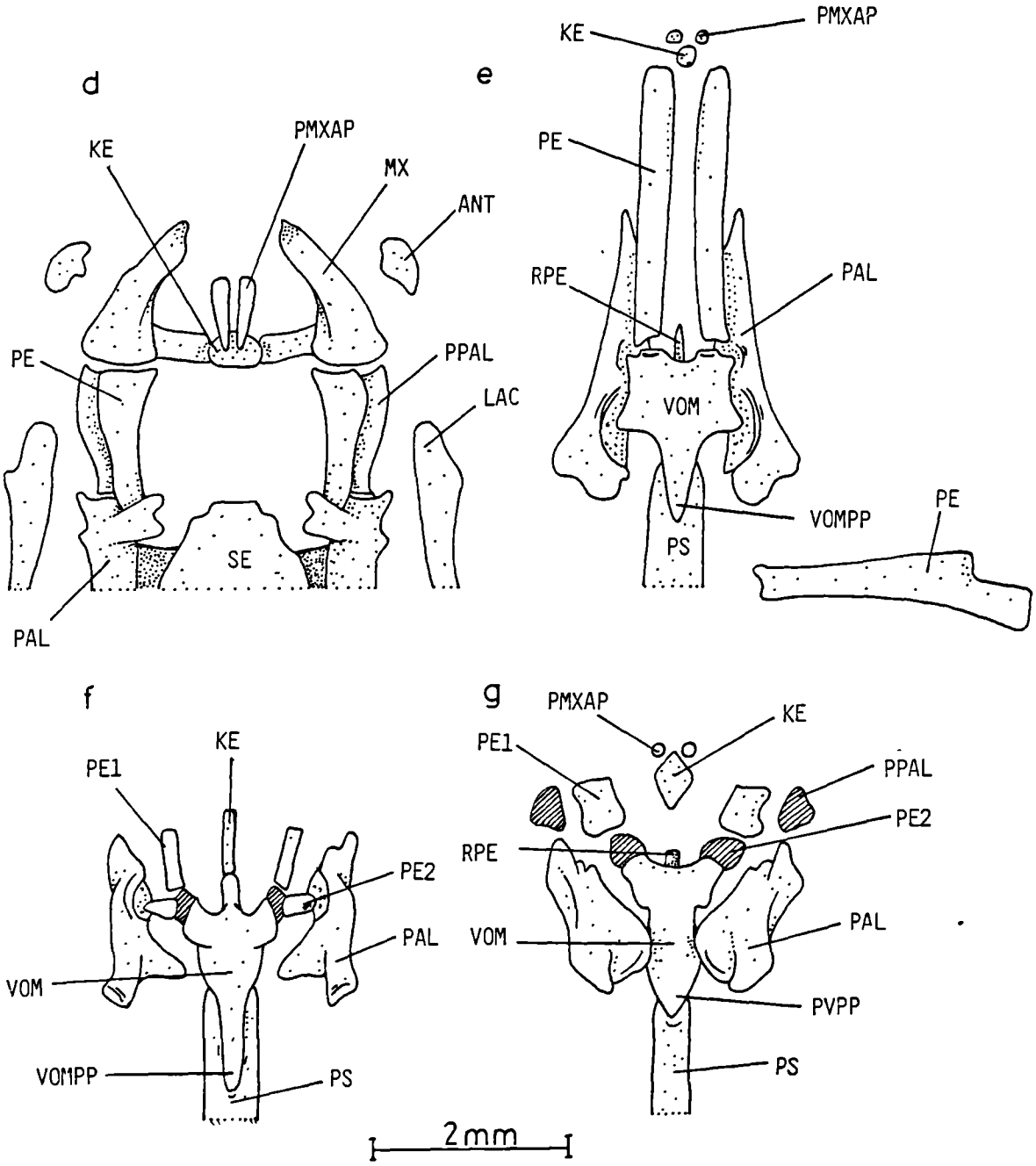

d
KE
PMXAP
MX
ANT
PE
PPAL
LAC
SE
PAL
e
KE
PMXAP
PE
RPE
PAL
VOM
VOMPP
PS
PE
f
PE1
KE
PE2
PAL
VOM
VOMPP
PS
g
PMXAP
KE
PE1
PPAL
PE2
RPE
VOM
PAL
PVPP
PS
2mm

Fig. xLiv Left palatine bone (Ventral view)

a. Lepidocephalus guntea

b. Somileptes gongota

c. Leptobotia fasciata

d. Botia macracantha

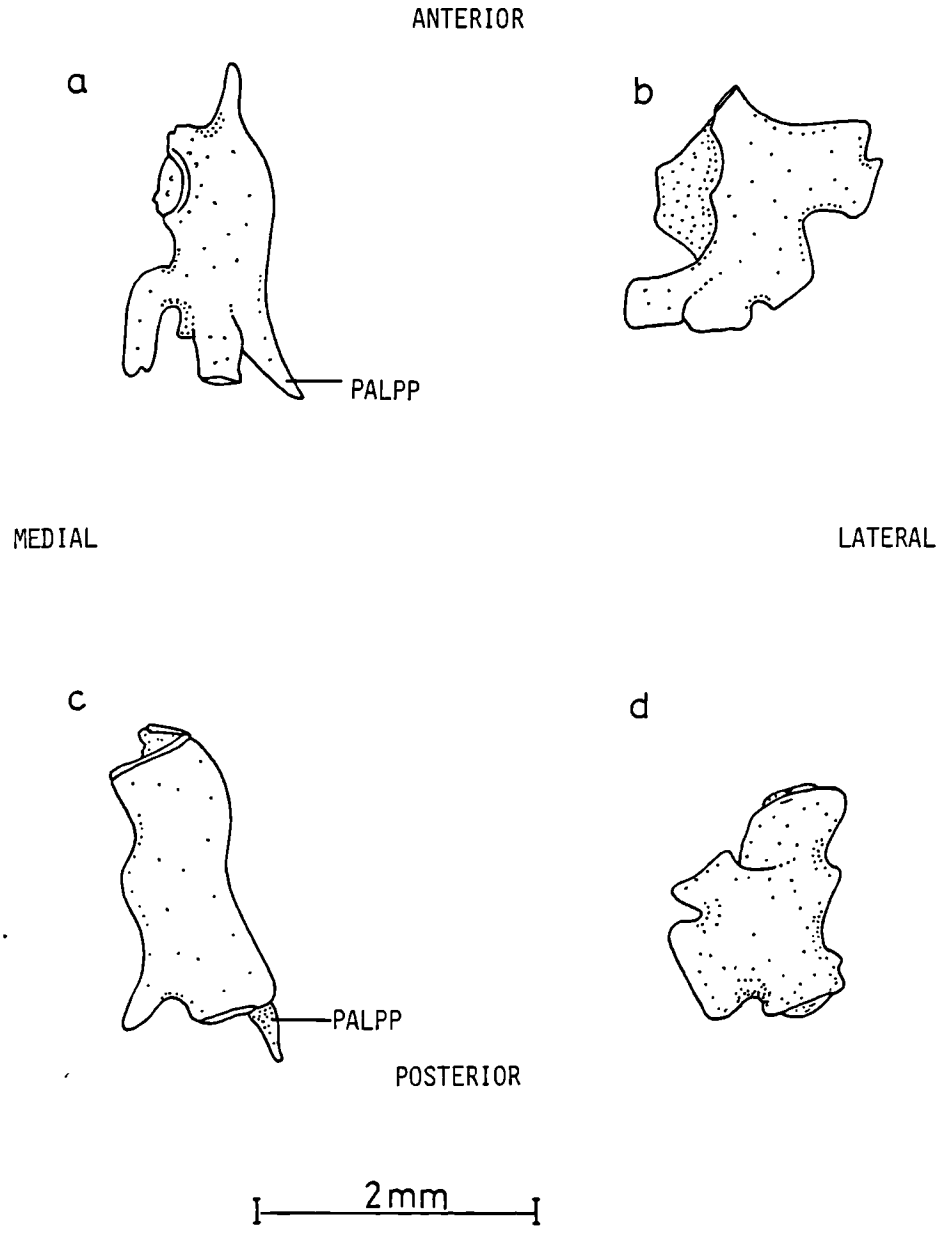

ANTERIOR
a
b
PALPP
MEDIAL
LATERAL
c
d
PALPP
POSTERIOR
2mm

Fig. xLv Ethmoprevomerine region. Left, dorsal view, right, ventral view.

a. Noemacheilus nigromaculatus

b. Noemacheilus montanus

c. Acanthophthalmus muraeniformis

d. Botia macracantha

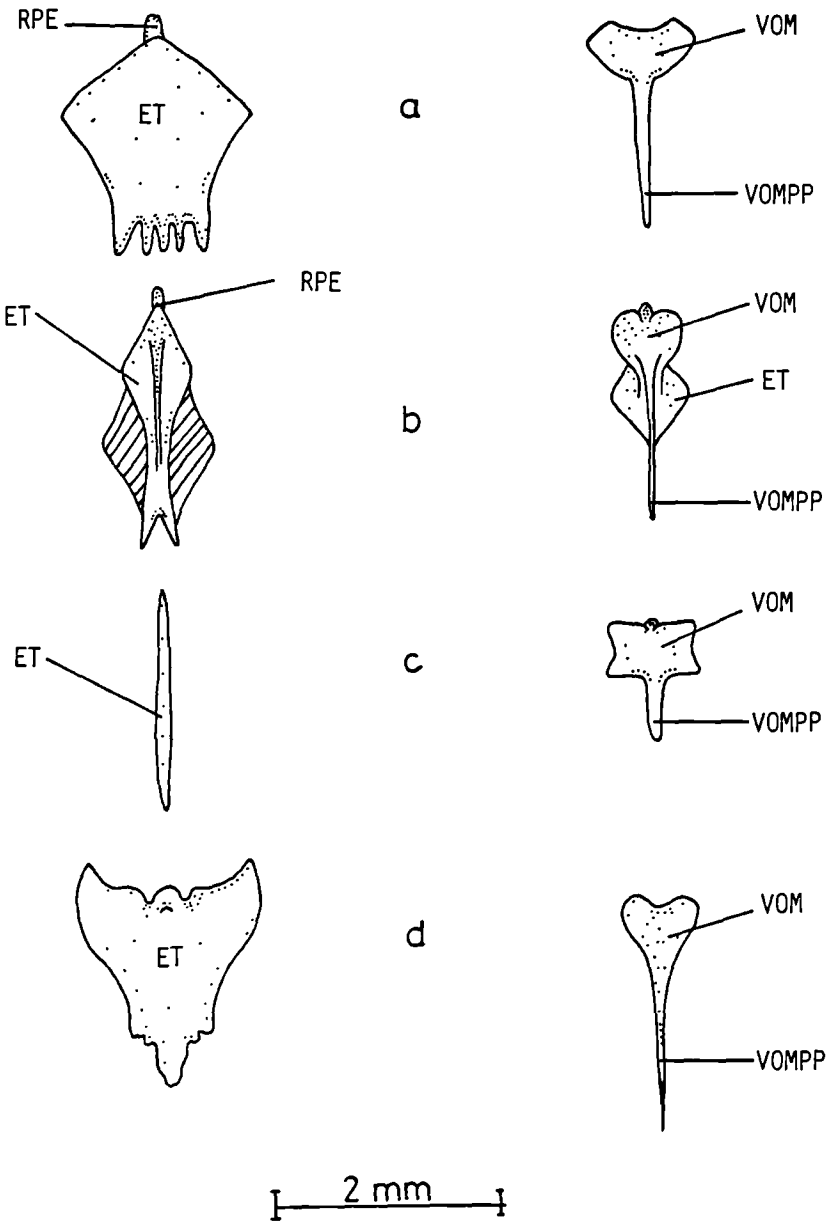

RPE
ET
a
VOM
VOMPP
ET
RPE
b
VOM
ET
VOMPP
ET
c
VOM
VOMPP
ET
d
VOM
VOMPP
2 mm

Fig. xLvi Diagrammatic figure showing the mobile ethmoid characteristic of the Cobitini (Right lateral view)

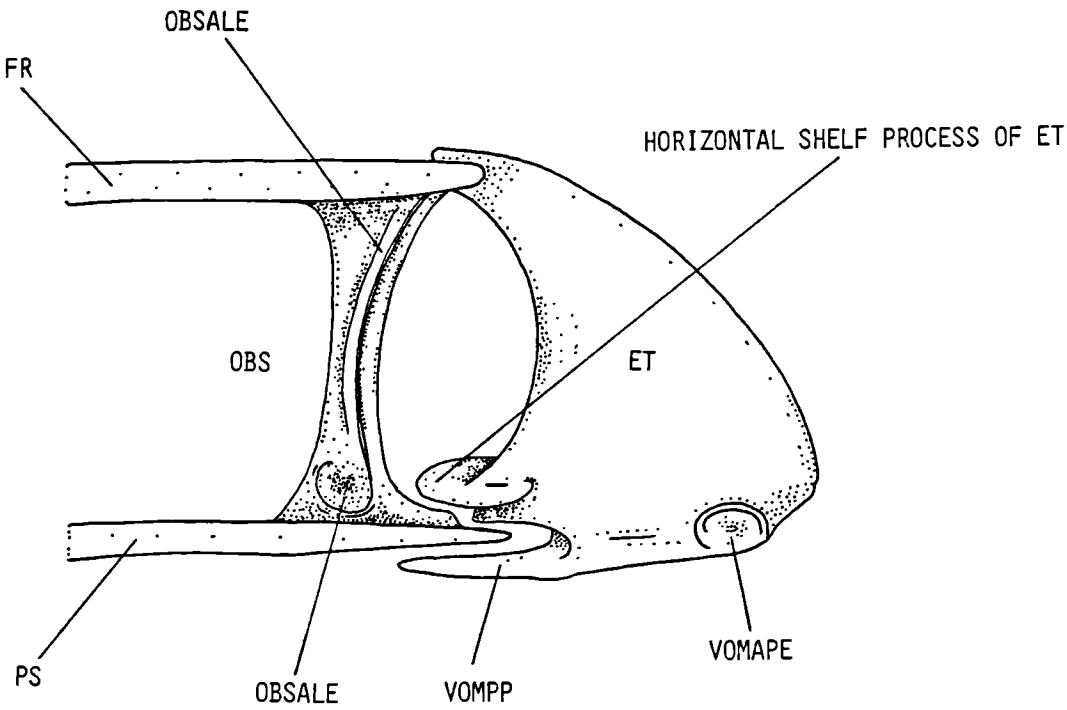

OBSALE
FR
HORIZONTAL SHELF PROCESS OF ET
OBS
ET
PS
OBSALE
VOMPP
VOMAPE
2mm

Fig. xLvii Branching diagram showing hypothesis of relationship of cobitoids based on ethmoprevomerine characteristics.

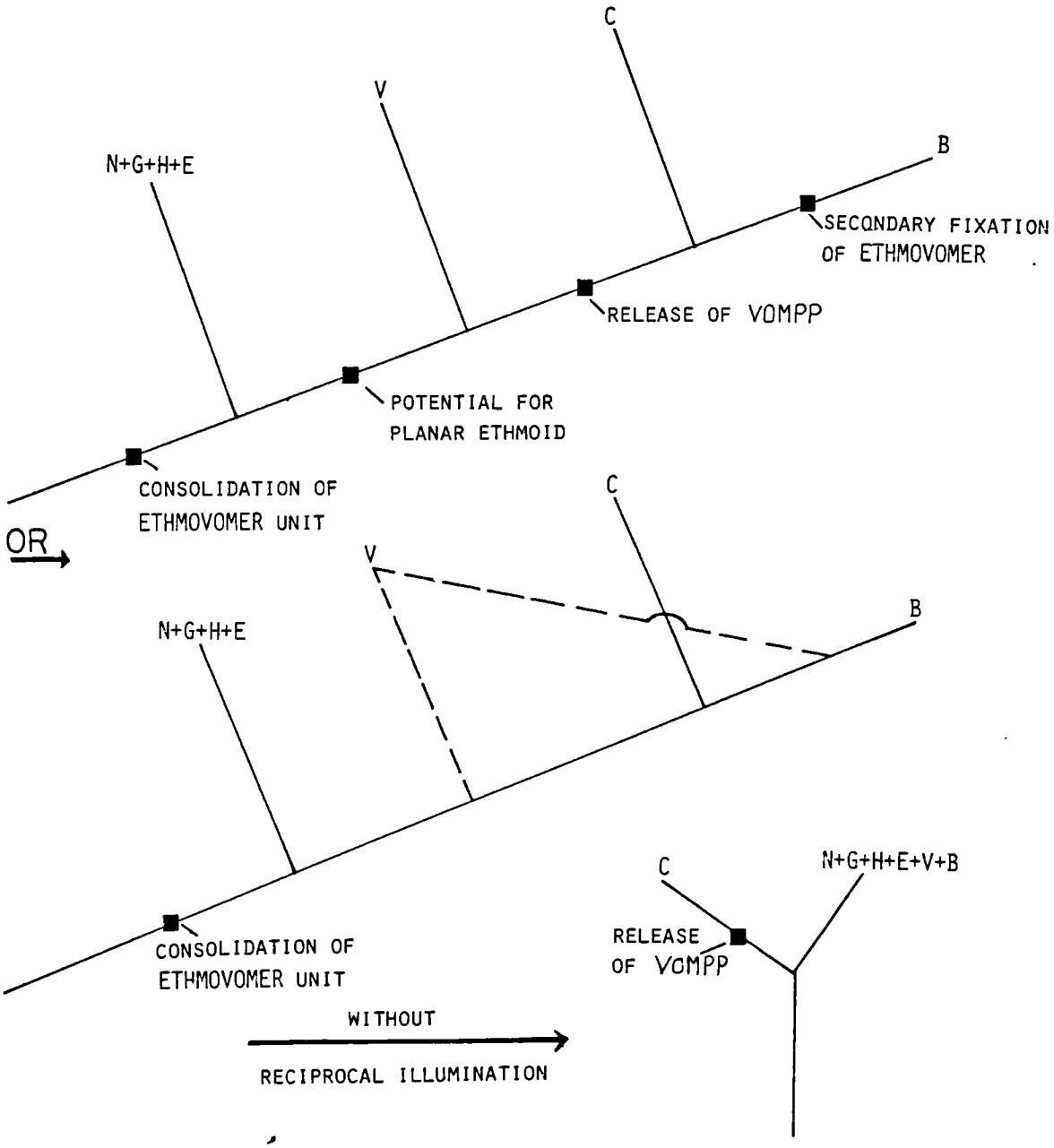

C
V
B
N+G+H+E
SECONDARY FIXATION
OF ETHMOVOMER
RELEASE OF VOMPP
POTENTIAL FOR
PLANAR ETHMOID
CONSOLIDATION OF
ETHMOVOMER UNIT
OR
C
V
B
N+G+H+E
CONSOLIDATION OF
ETHMOVOMER UNIT
C
N+G+H+E+V+B
RELEASE
OF VOMPP
WITHOUT
RECIPROCAL ILLUMINATION

Fig. xLviii Right suborbital spine [Right lateral view]

a. Lepidocephalus caudofurcatus

b. Niwaella delicta

c. Misgurnus anguillicaudatus

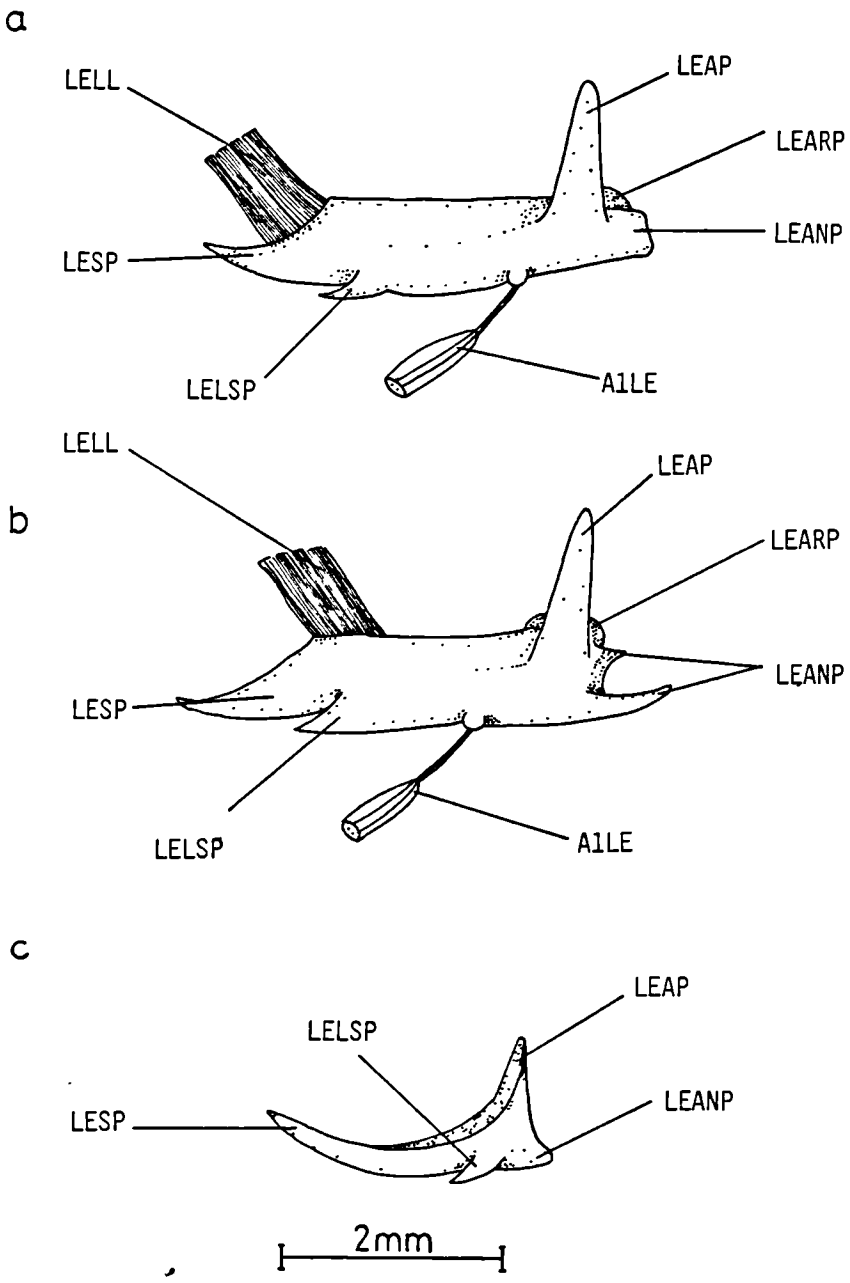

a
LELL
LEAP
LEARP
LEANP
LESP
LELSP
A1LE
b
LELL
LEAP
LEARP
LEANP
LESP
LELSP
A1LE
c
LEAP
LELSP
LEANP
LESP
2mm

Fig. xLix Right suborbital spine [Right lateral view]

a. Botia almorhae

b. Braincase socket for right suborbital spine of Botia almorhae

c. Leptobotia elongata

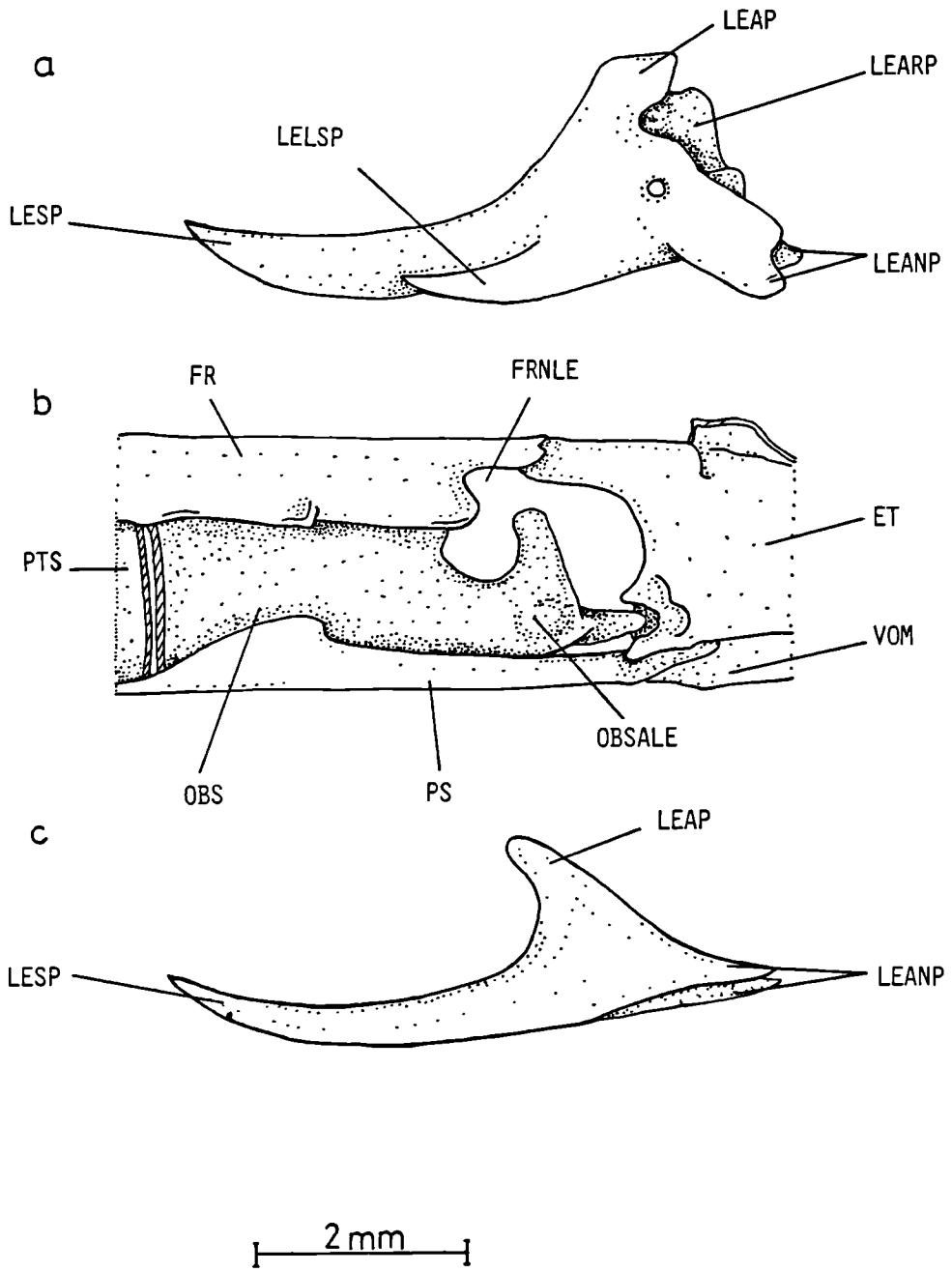

a
LEAP
LEARP
LELSP
LESP
LEANP
b
FR
FRNLE
ET
PTS
VOM
OBSALE
OBS
PS
c
LEAP
LESP
LEANP
2 mm

Fig. L Left lateral ethmoid in Noemacheilini

a. Superficial lachrymal pad in *Noemacheilus montanus*

b. Lateral ethmoid in male *Noemacheilus botia*

c. Lateral ethmoid in female *Noemacheilus botia*

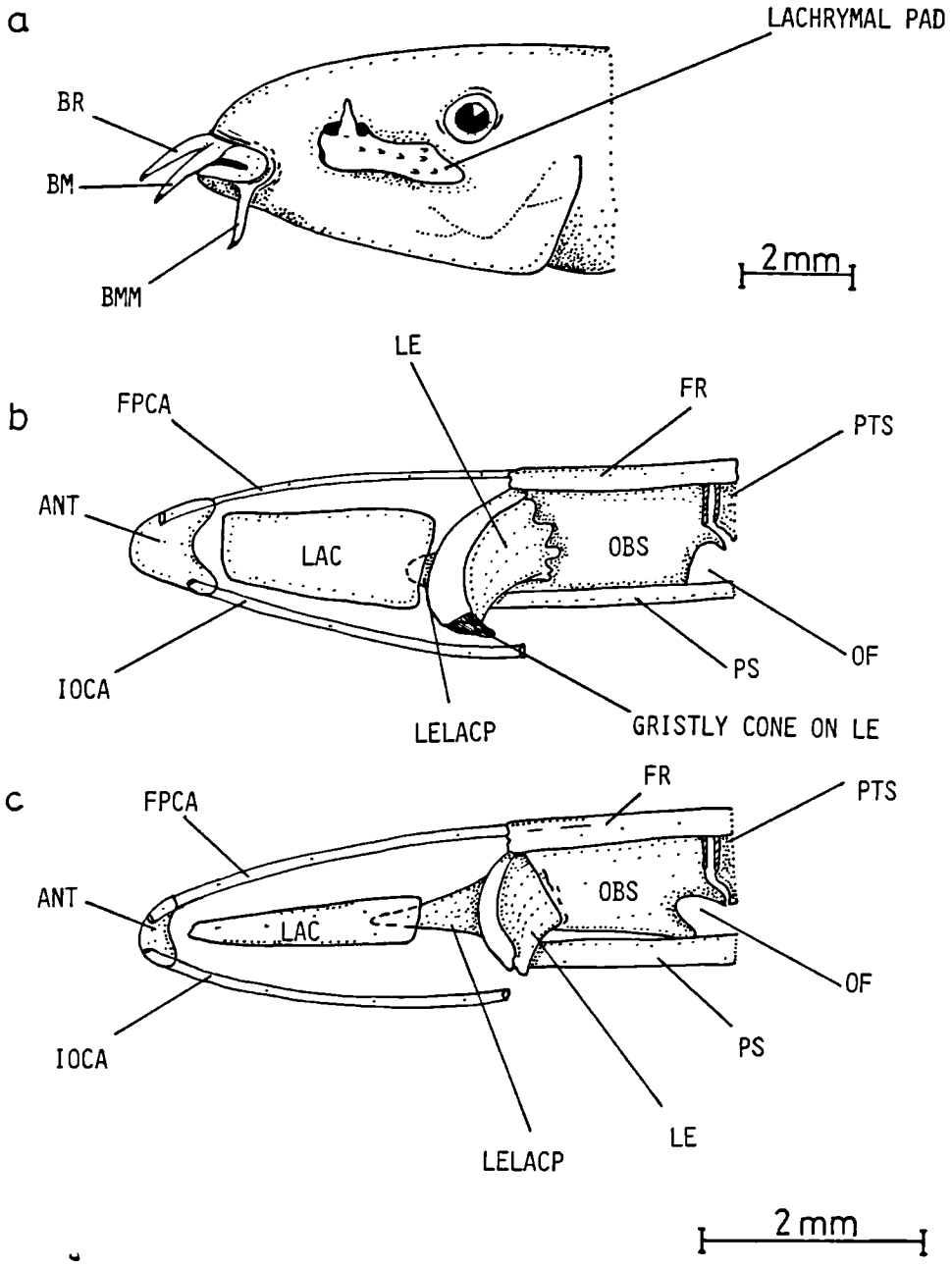

a
LACHRYMAL PAD
BR
BM
BMM
2 mm
b
LE
FPCA
FR
PTS
ANT
LAC
OBS
IOCA
PS
OF
LELACP
GRISTLY CONE ON LE
c
FPCA
FR
PTS
ANT
OBS
LAC
OF
IOCA
PS
LE
LELACP
2 mm

Fig. Li Right lateral ethmoid of Psilorhynchus

a. Lateral view

b. Posterior view

c. Anterior view

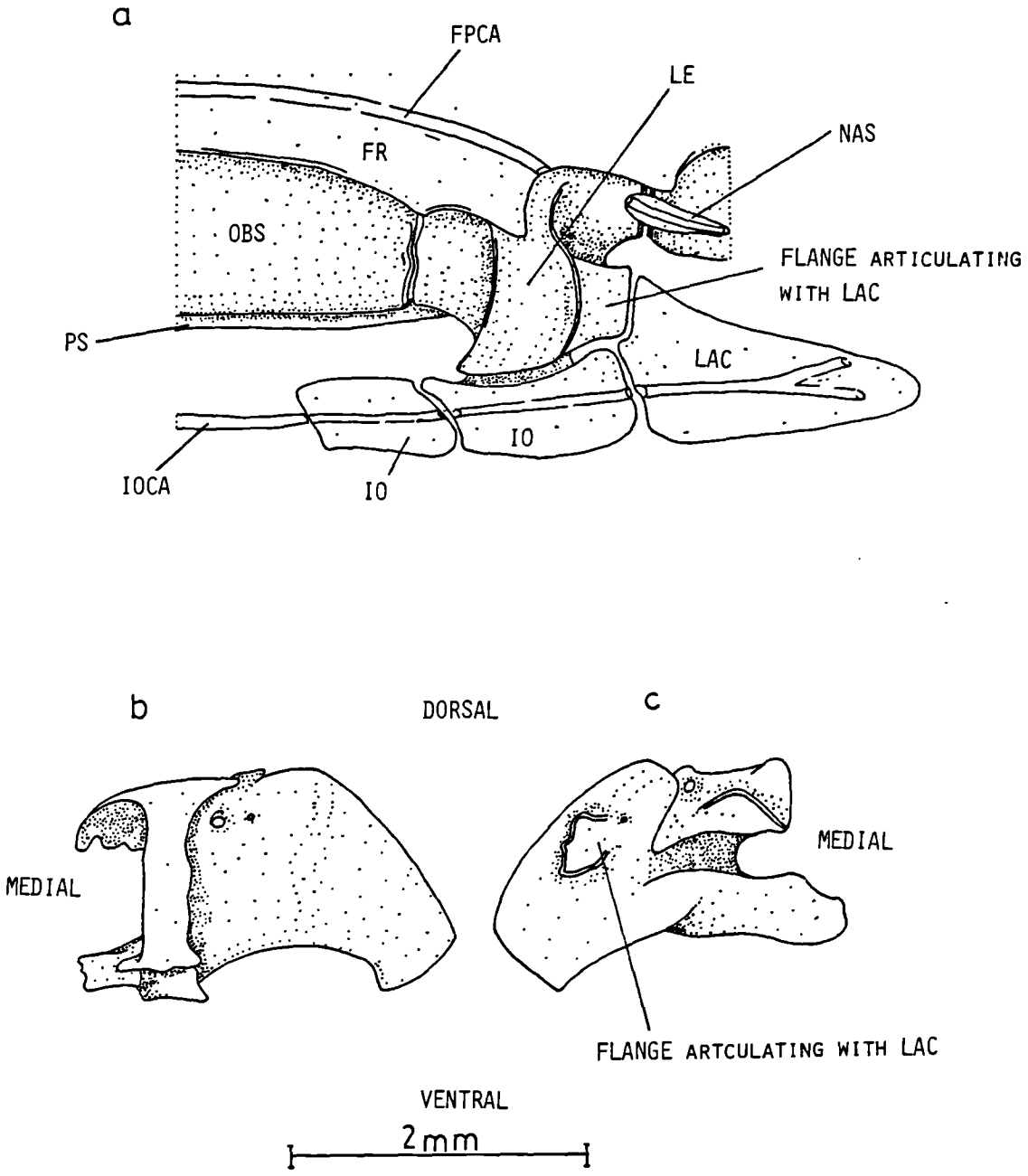

a
FPCA
LE
NAS
FR
OBS
FLANGE ARTICULATING
WITH LAC
PS
LAC
IO
IOCA
IO
b
DORSAL
c
MEDIAL
MEDIAL
FLANGE ARTCULATING WITH LAC
VENTRAL
2mm

Fig. Lii Orbitosphenoid bone (Ventral view)

a. Oronectes platycephalus

b. Cobitis taenia

c. Botia modesta

d. Leptobotia fasciata

e. Psilorhynchus balitora - left, ventral view; right left lateral view]

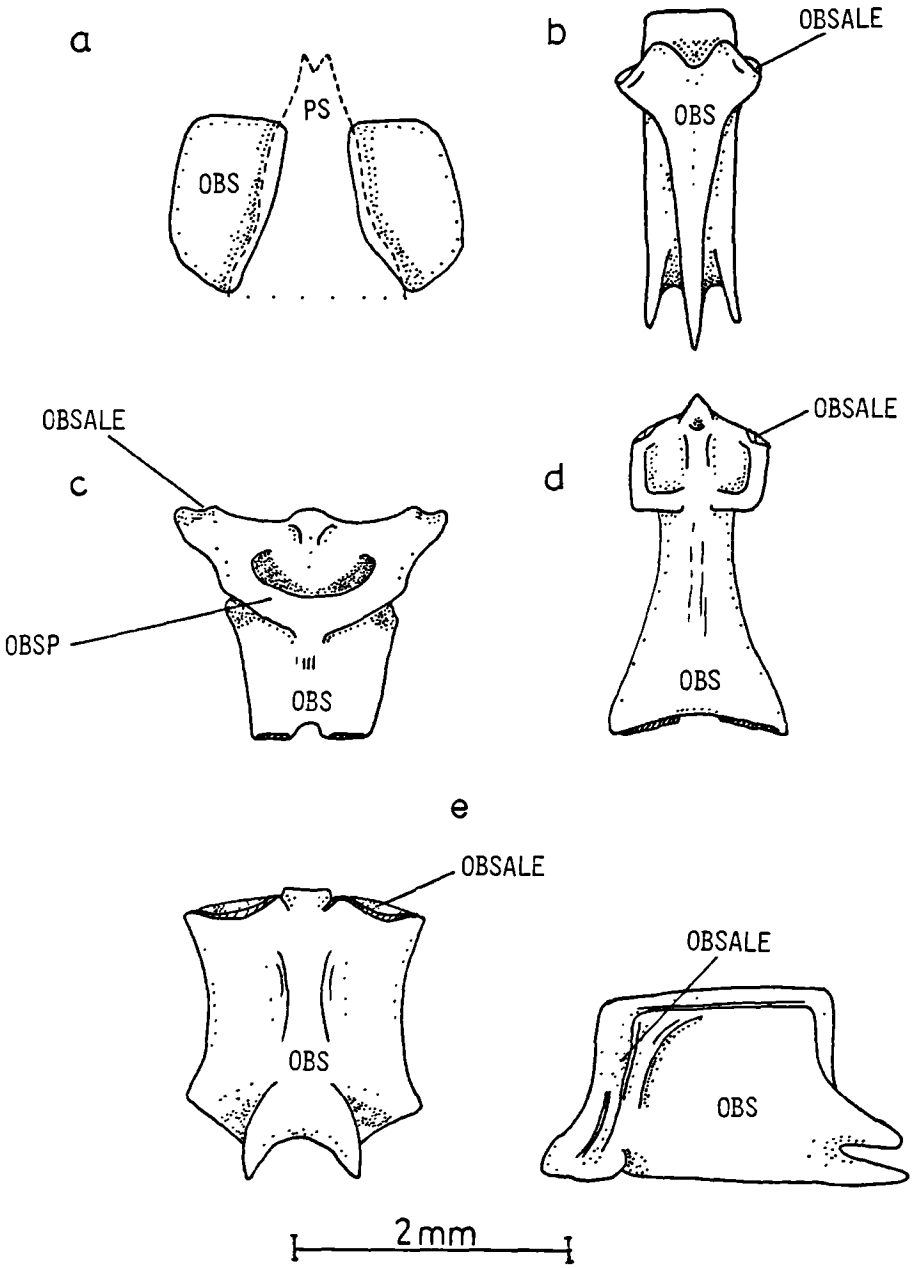

a
PS
OBS
b
OBSALE
OBS
OBSALE
c
OBSP
OBS
d
OBSALE
OBS
e
OBSALE
OBS
OBSALE
OBS
2mm

Fig. Liii Pterosphenoid bone

a. Noemacheilus corica (Ventral view right)

b. Noemacheilus strauchi
(Ventral view right)

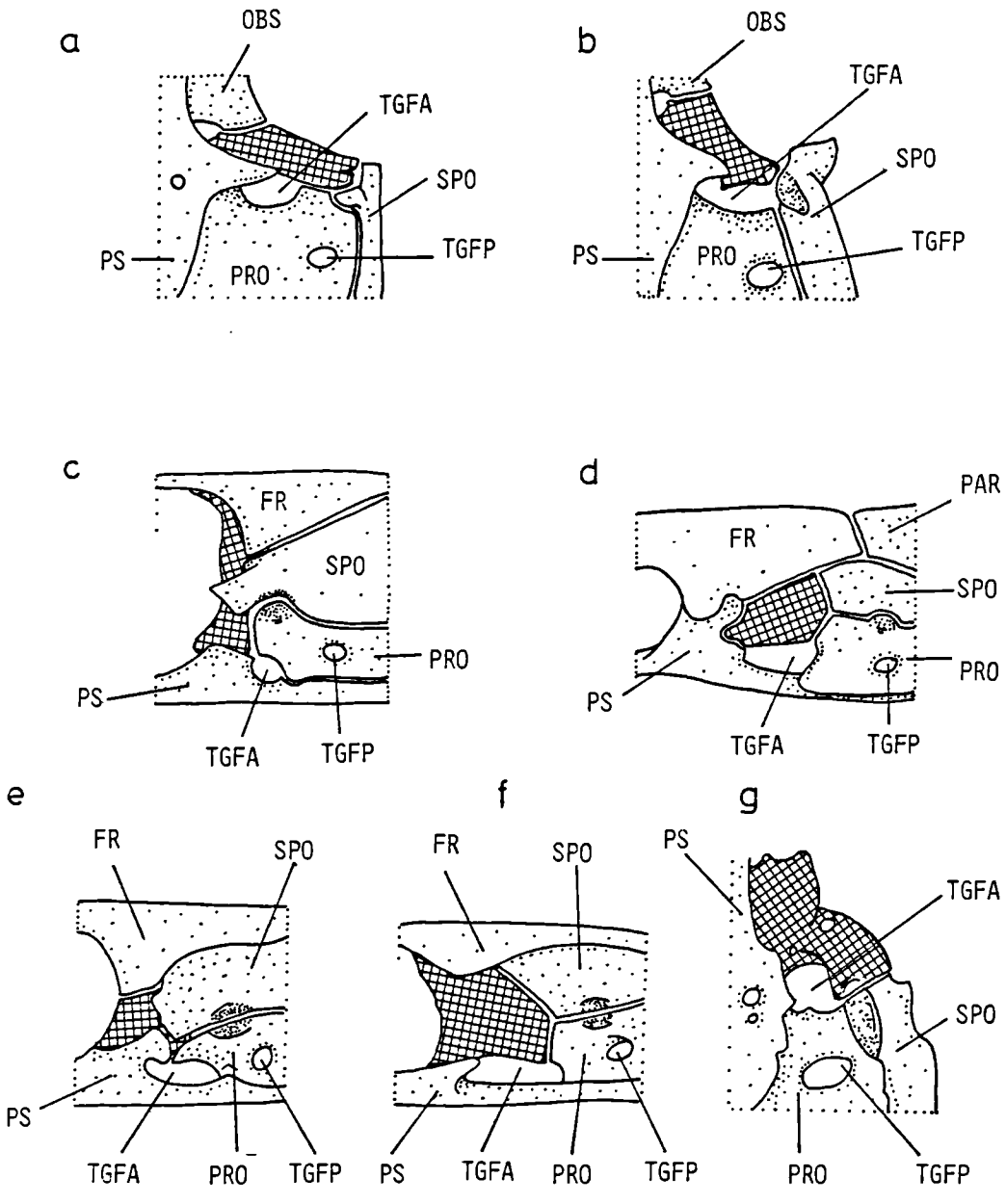
c. Acanthopsis choirorhynchus
(Lateral view left)

d. Acanthophthalmus semicinctus
(Lateral view left)

e. Cobitis taenia bilineata
(Lateral view left)

f. Misgurnus anguillicaudatus
(Lateral view left)

g. Botia berdmorei (Ventral view right)


a
OBS
TGFA
SPO
PS
PRO
TGFP
b
OBS
TGFA
SPO
PS
PRO
TGFP
c
FR
SPO
PRO
PS
TGFA
TGFP
d
PAR
FR
SPO
PRO
PS
TGFA
TGFP
e
FR
SPO
PS
TGFA
PRO
TGFP
f
FR
SPO
PS
TGFA
PRO
TGFP
g
PS
TGFA
SPO
PRO
TGFP

NOT TO SCALE

Fig. Liv Anterior trigeminal foramen (Ventral view, right foramen)

a. Lefua nikkonis

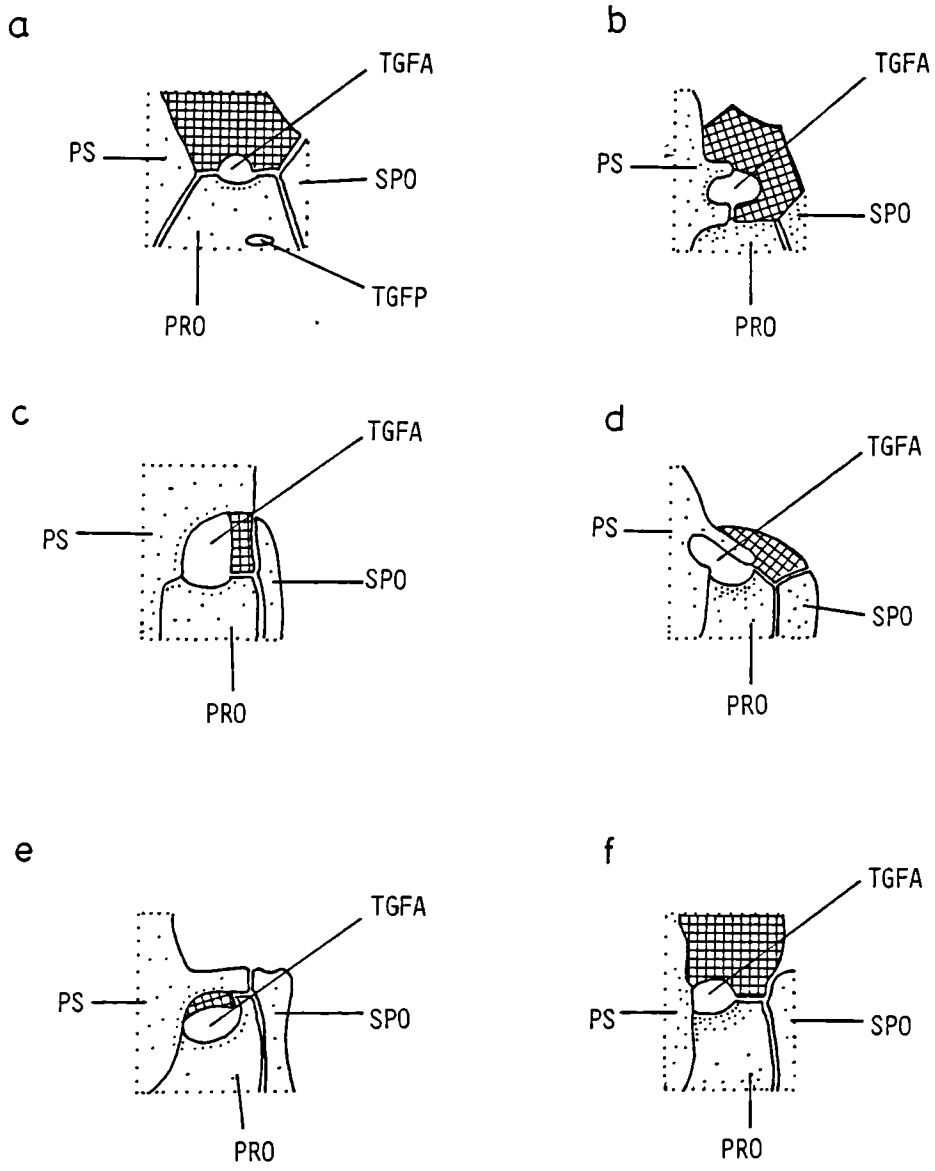
b. Oronectes platycephalus

c. Acanthophthalmus muraeniformis

d. Lepidocephalus caudofurcatus

e. Acanthopsis choirorhynchus

f. Botia hymenophysa


a
TGFA
PS
SPO
TGFP
PRO
b
TGFA
PS
SPO
PRO
c
TGFA
PS
SPO
PRO
d
TGFA
PS
SPO
PRO
e
TGFA
PS
SPO
PRO
f
TGFA
PS
SPO
PRO

NOT TO SCALE

Fig. Lv Posterior braincase osteology of *Acanthopsis choirorhynchus* [right lateral view]

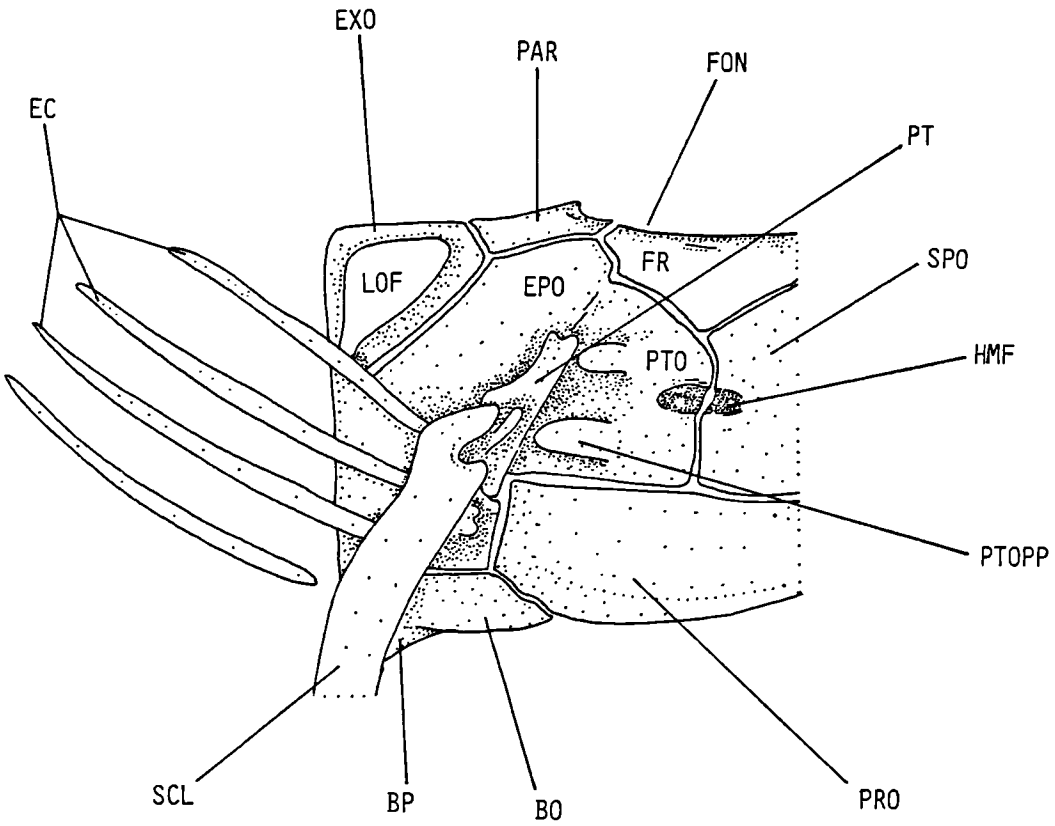

EXO
PAR
FON
EC
PT
LOF
EPO
FR
SPO
PTO
HMF
PTOPP
SCL
BP
BO
PRO
2mm

Fig. Lvi Posterior braincase osteology (Dorsal view)

a. Noemacheilus yarkandensis

b. Lepidocephalus thermalis

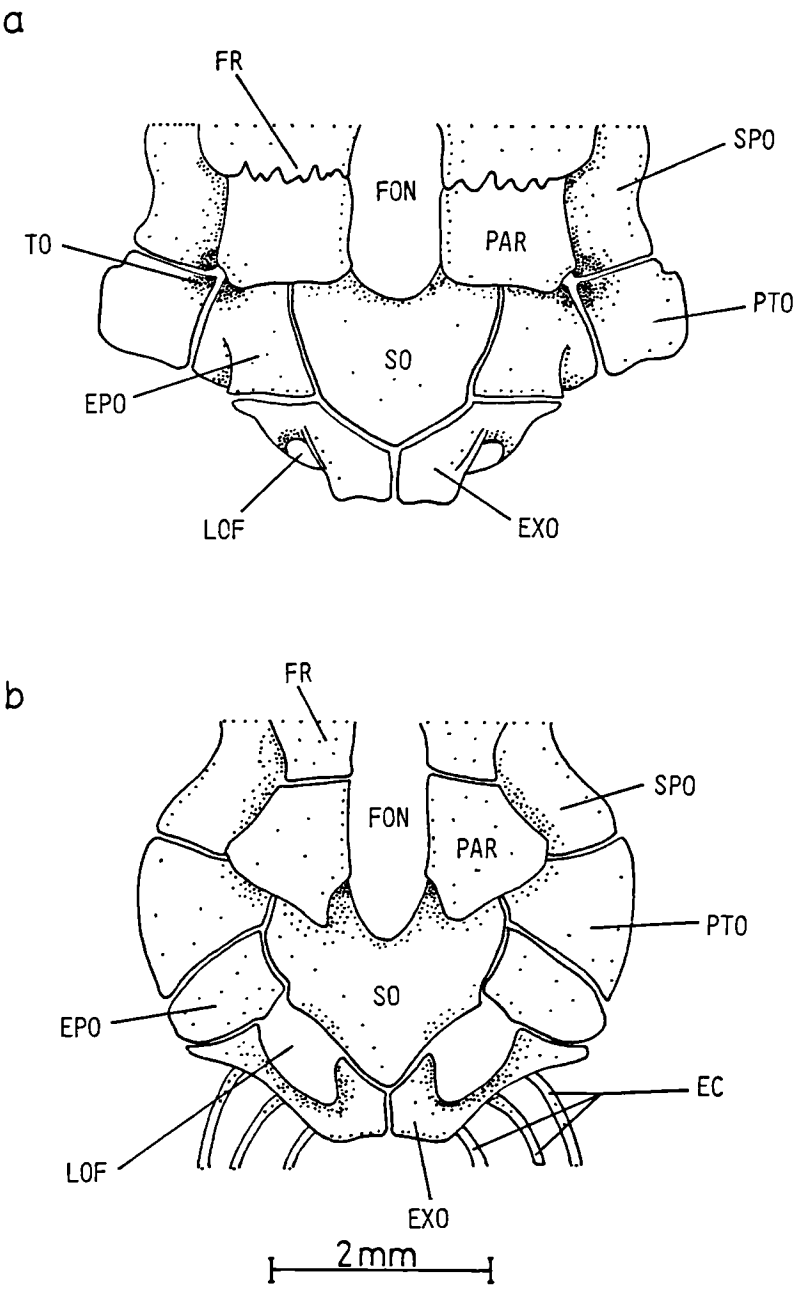

a
FR
FON
SPO
TO
PAR
PTO
SO
EPO
LOF
EXO
b
FR
SPO
FON
PAR
PTO
SO
EPO
EC
LOF
EXO
2mm

Fig. Lvii Posterior braincase osteology

a. Leptobotia elongata (Dorsal view)

b. Botia berdmorei (Left dorsolateral view)

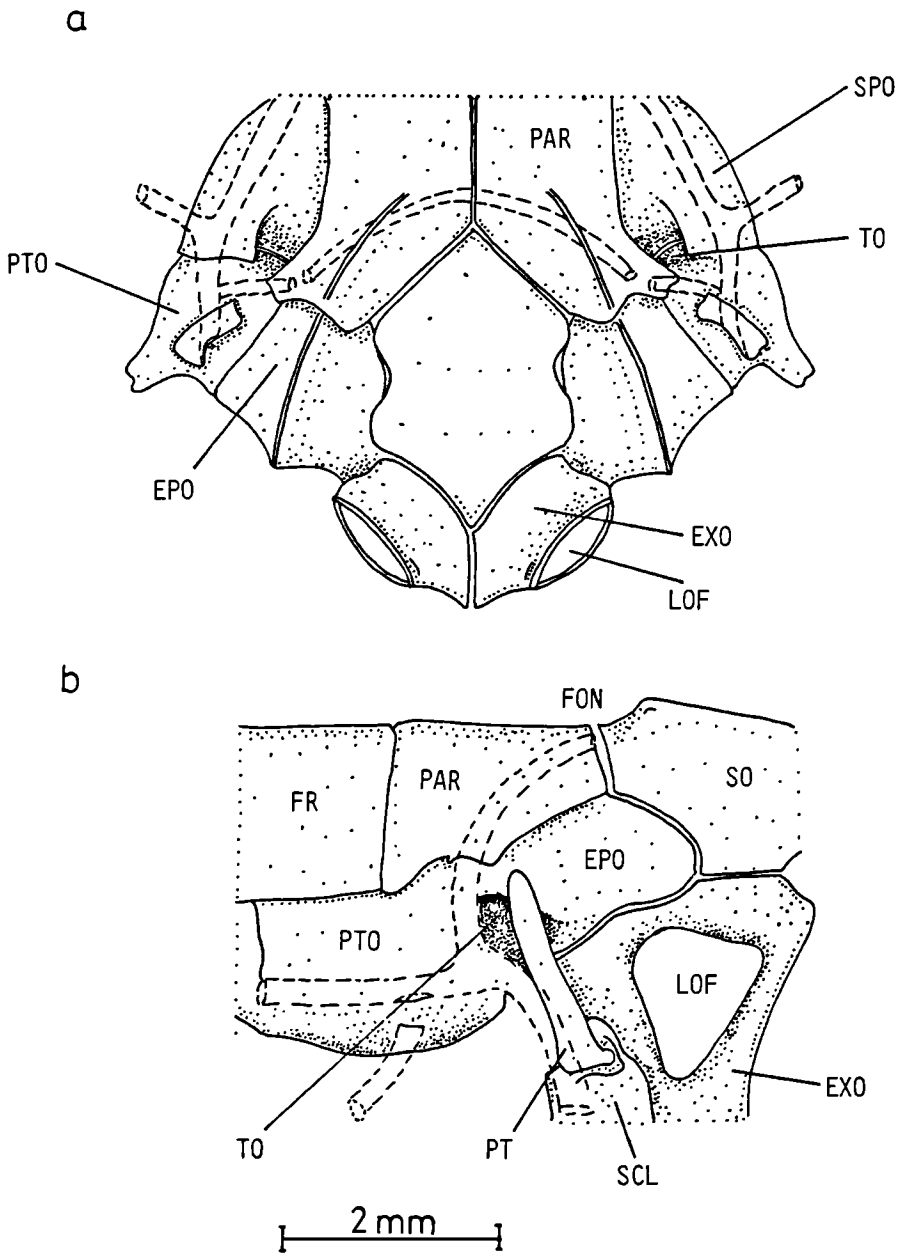

a
SPO
PAR
TO
PTO
EPO
EXO
LOF
b
FON
FR
PAR
SO
EPO
PTO
LOF
EXO
TO
PT
SCL
2 mm

Fig. Lviii Basioccipital osteology [Posterior view]

a. Ellopostoma

b. Catostomus [from Weisel, 1960]

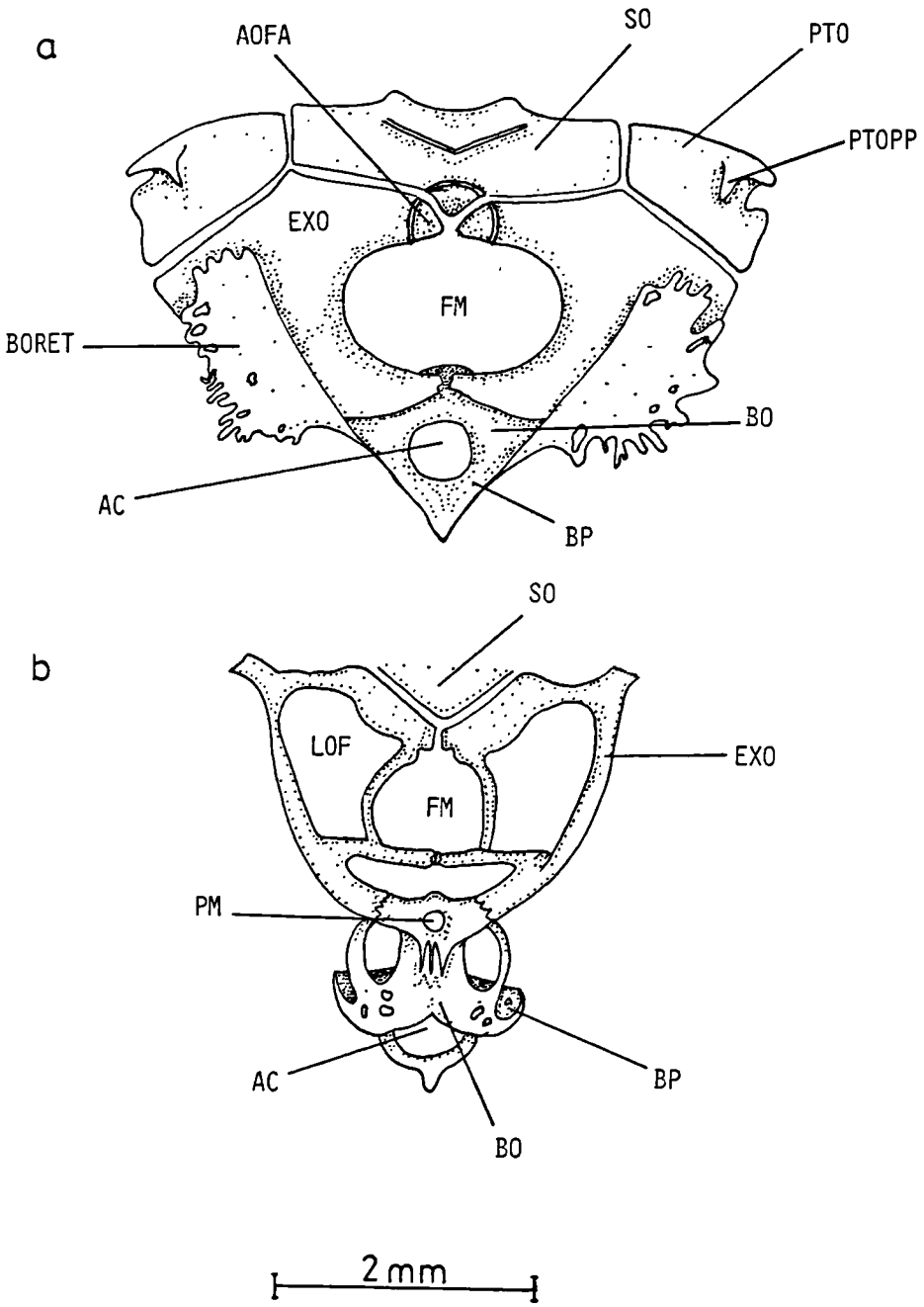

a
AOFA
SO
PTO
PTOPP
EXO
FM
BORET
BO
AC
BP
b
SO
LOF
EXO
FM
PM
AC
BP
BO
2 mm

Fig. Lvix Pharyngeal processes of the basioccipital (Ventral view)

a. Noemacheilus montanus

b. Noemacheilus botia (Left, ventral view, right, left lateral view)

c. Lepidocephalus caudofurcatus

d. Acanthopsis choirorhynchus

e. Somileptes gongota

f. Sabanejewia aurata balconica

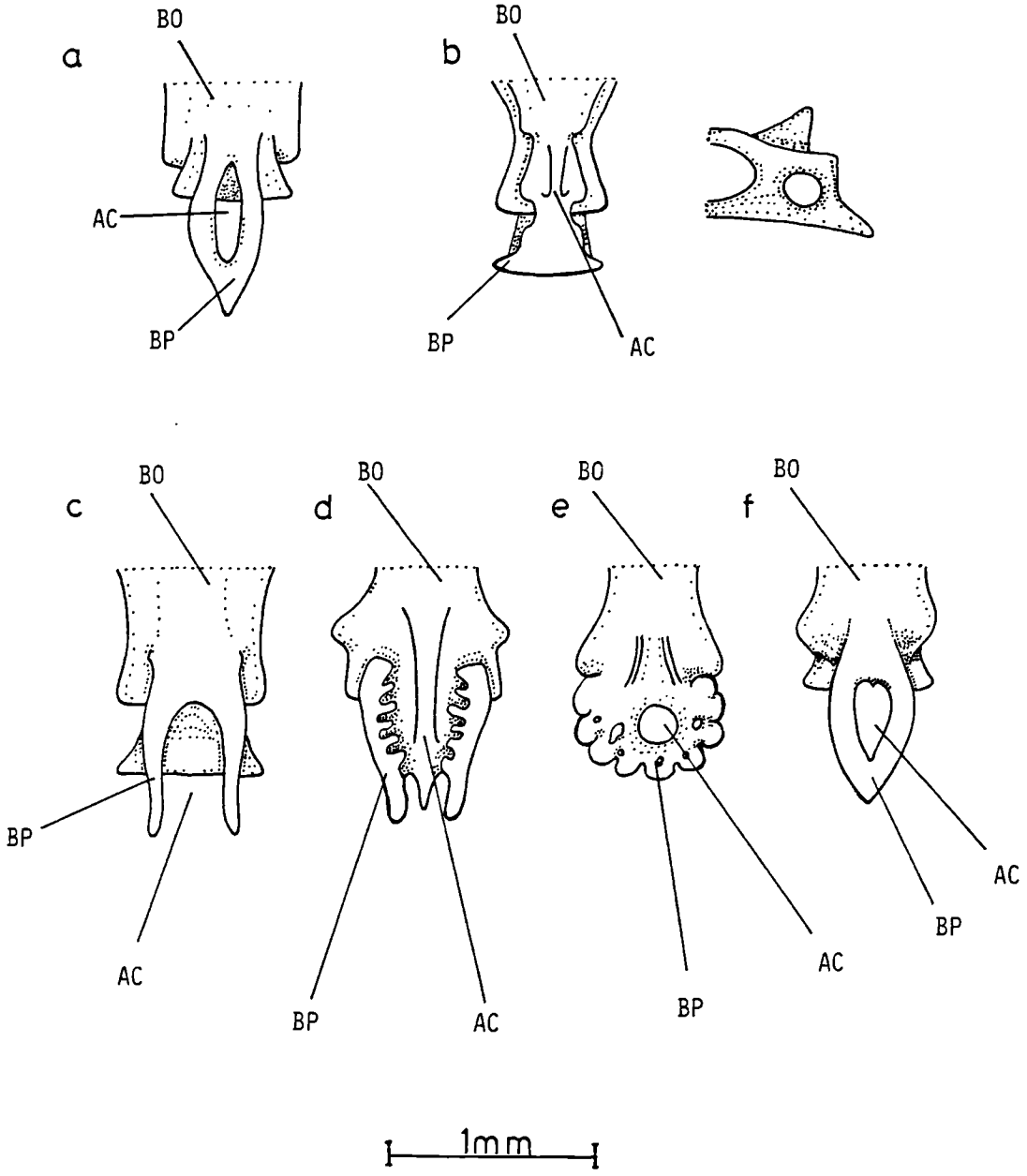

a
BO
AC
BP
b
BO
BP
AC
c
BO
BP
AC
d
BO
BP
AC
e
BO
BP
AC
f
BO
AC
BP
1mm

Fig. Lx Parasphenoid bone (Ventral view)

a. Noemacheilus montanus

b. Lefua nikkonis

c. Sabanejewia aurata balconica

d. Leptobotia fasciata

e. Botia hymenophysa

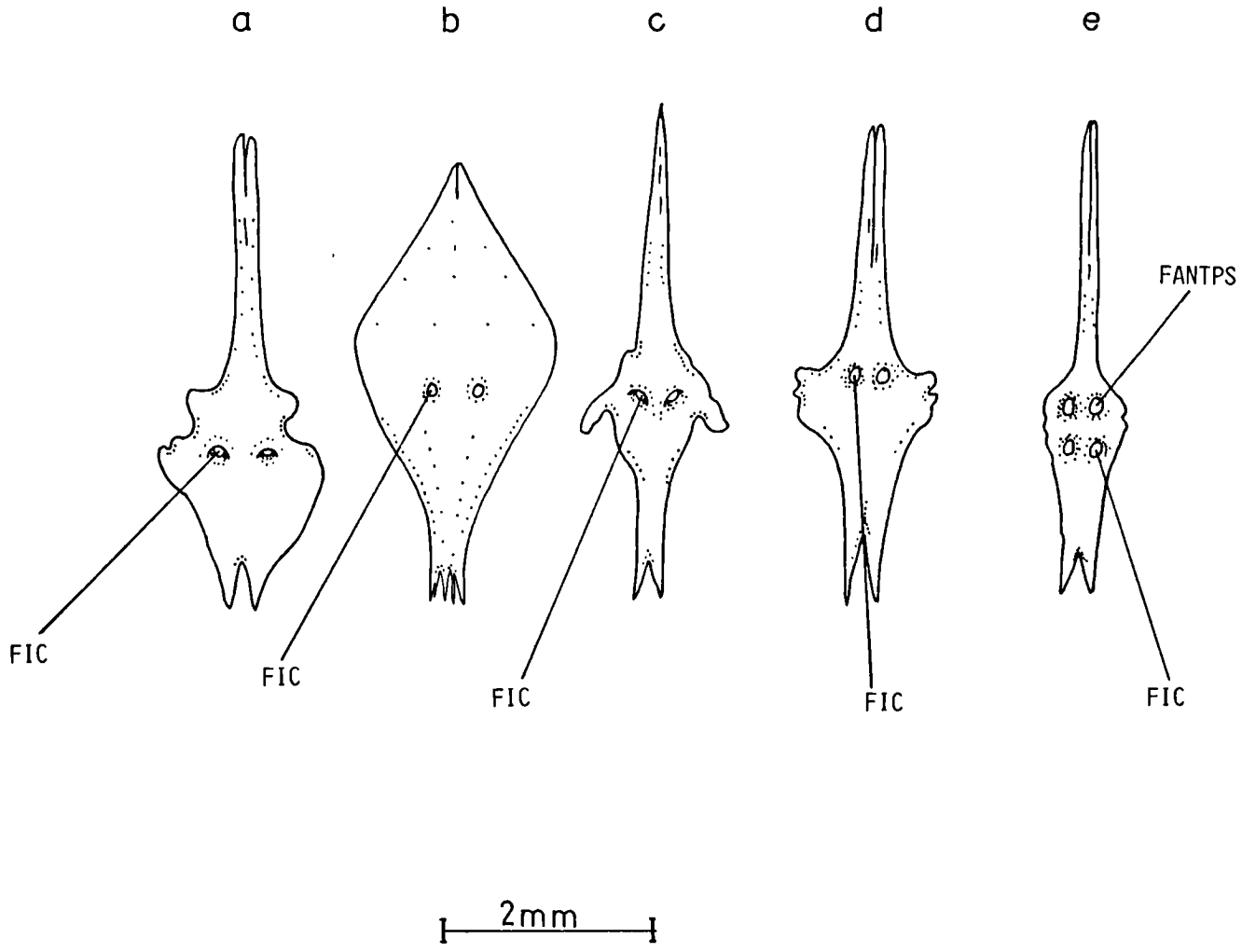

a
b
c
d
e
FANTPS
FIC
FIC
FIC
FIC
FIC
2mm

Fig. Lxi Right frontal and parietal bone

a. Noemacheilus montanus

b. Oronectes platycephalus

c. Noemacheilus strauchi

d. Ellopostoma

e. Vaillantella

f. Misgurnus anguillicaudatus

g. Lepidocephalus thermalis

h. Acanthopsis choirorhynchus

i. Somileptes gongota

j. Acanthophthalmus muraeniformis

k. Leptobotia fasciata

l. Botia almorhae

m. Botia berdmorei

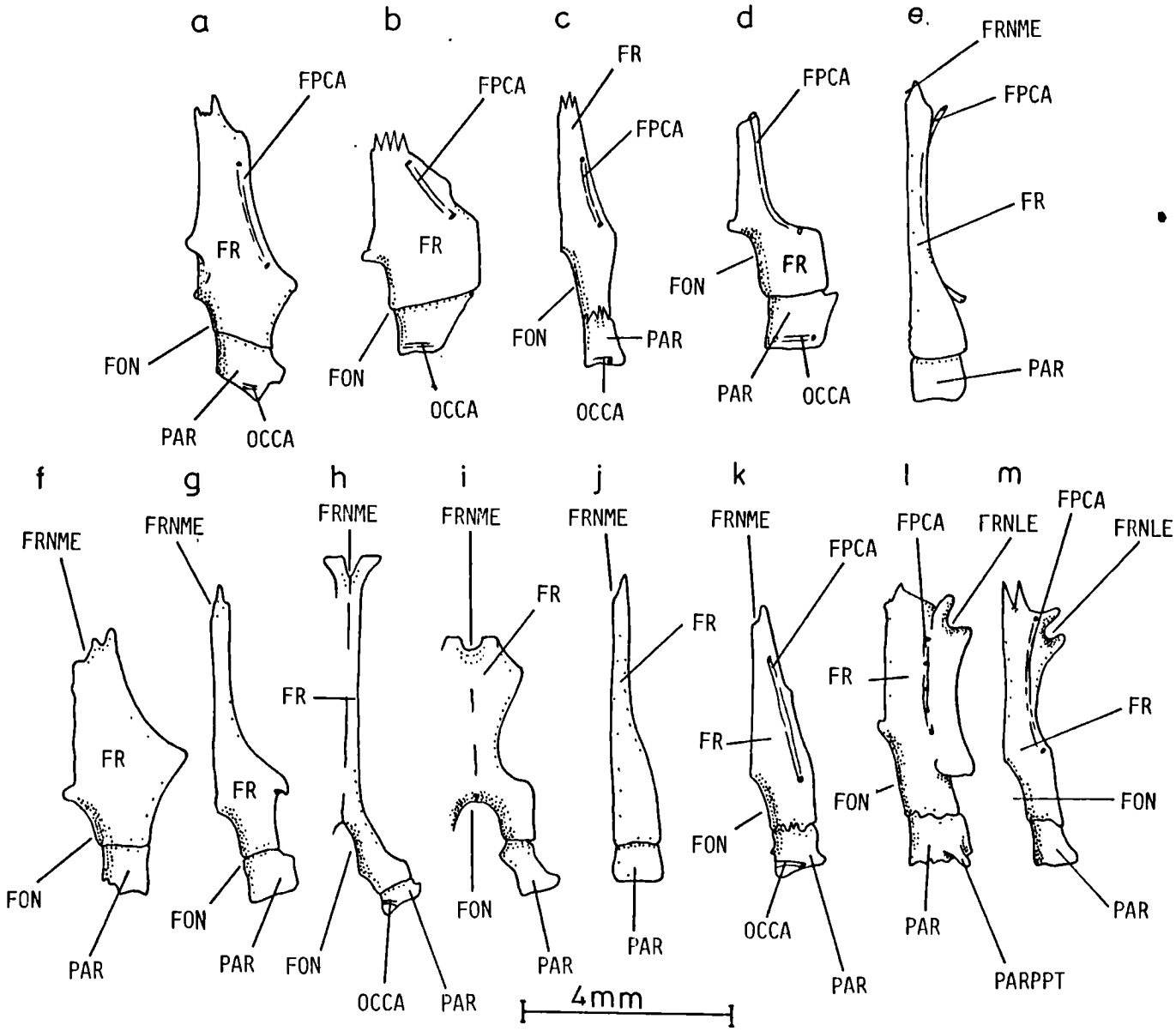

a
b
c
d
e
FPCA
FR
FON
PAR
OCCA
FRNME
f
g
h
i
j
k
l
m
FRNLE
PARPPT
4mm

Fig. Lxii Posttemporal articulation

a. Ellopostoma (Dorsal view left)

b. Botia macracantha (Lateral view right)

c. Botia almorhae (Dorsal view left)

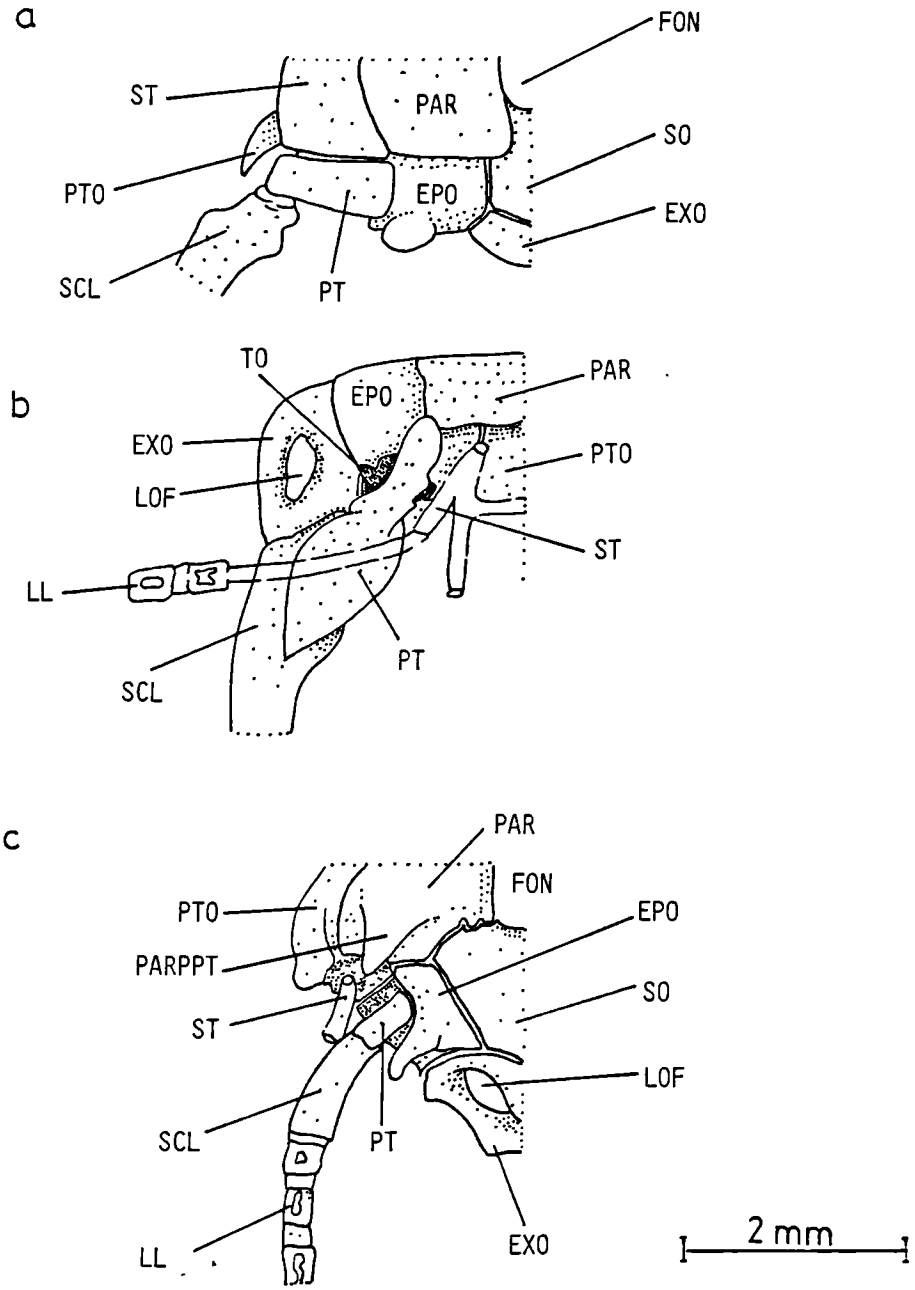

a
FON
ST
PAR
SO
PTO
EPO
EXO
SCL
PT
b
TO
EPO
PAR
EXO
PTO
LOF
ST
LL
PT
SCL
c
PAR
FON
PTO
EPO
PARPPT
SO
ST
LOF
SCL
PT
LL
EXO
2 mm

Fig. Lxiii Right posttemporal - supracleithrum

a. Aborichthus elongatus

b. Oronectes platycephalus

c. Lefua nikkonis

d. Lepidocephalus sp.

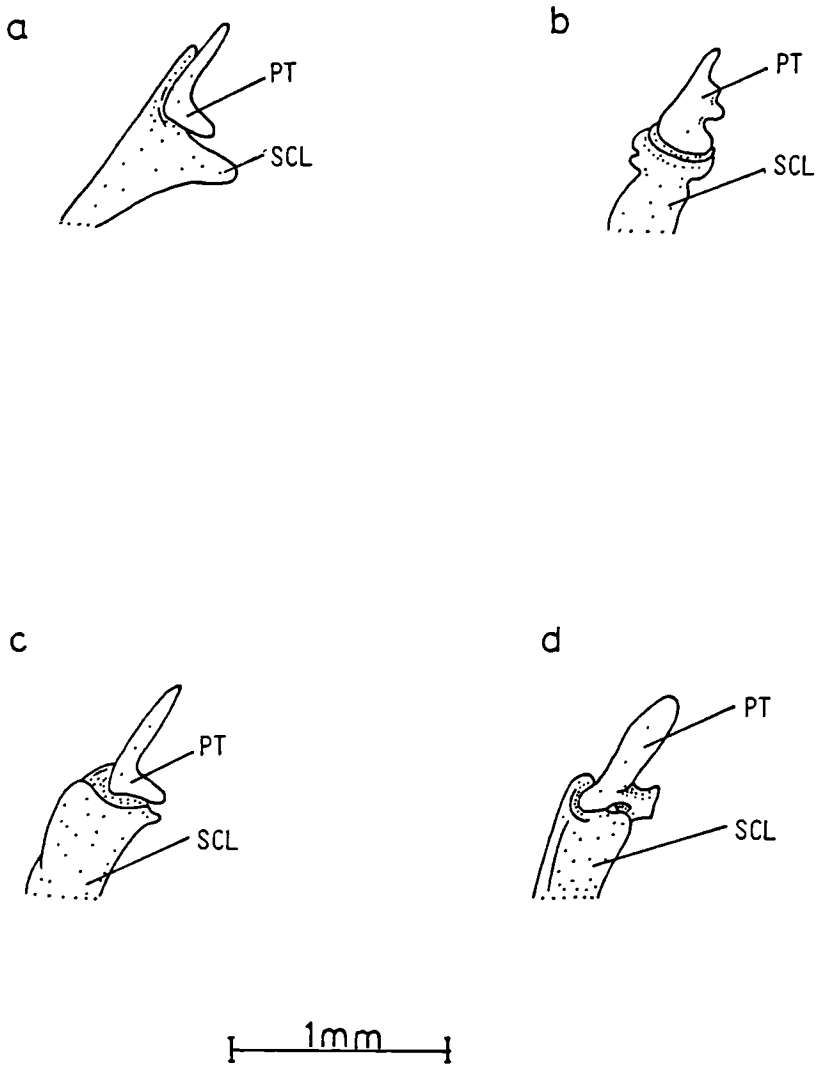

a
PT
SCL
b
PT
SCL
c
PT
SCL
d
PT
SCL
1mm

Fig. Lxiv Left pectoral skeleton (Medial view)

a. Noemacheilus montanus

b. Glaniopsis hanitschi

c. Ellopostoma megalomycter

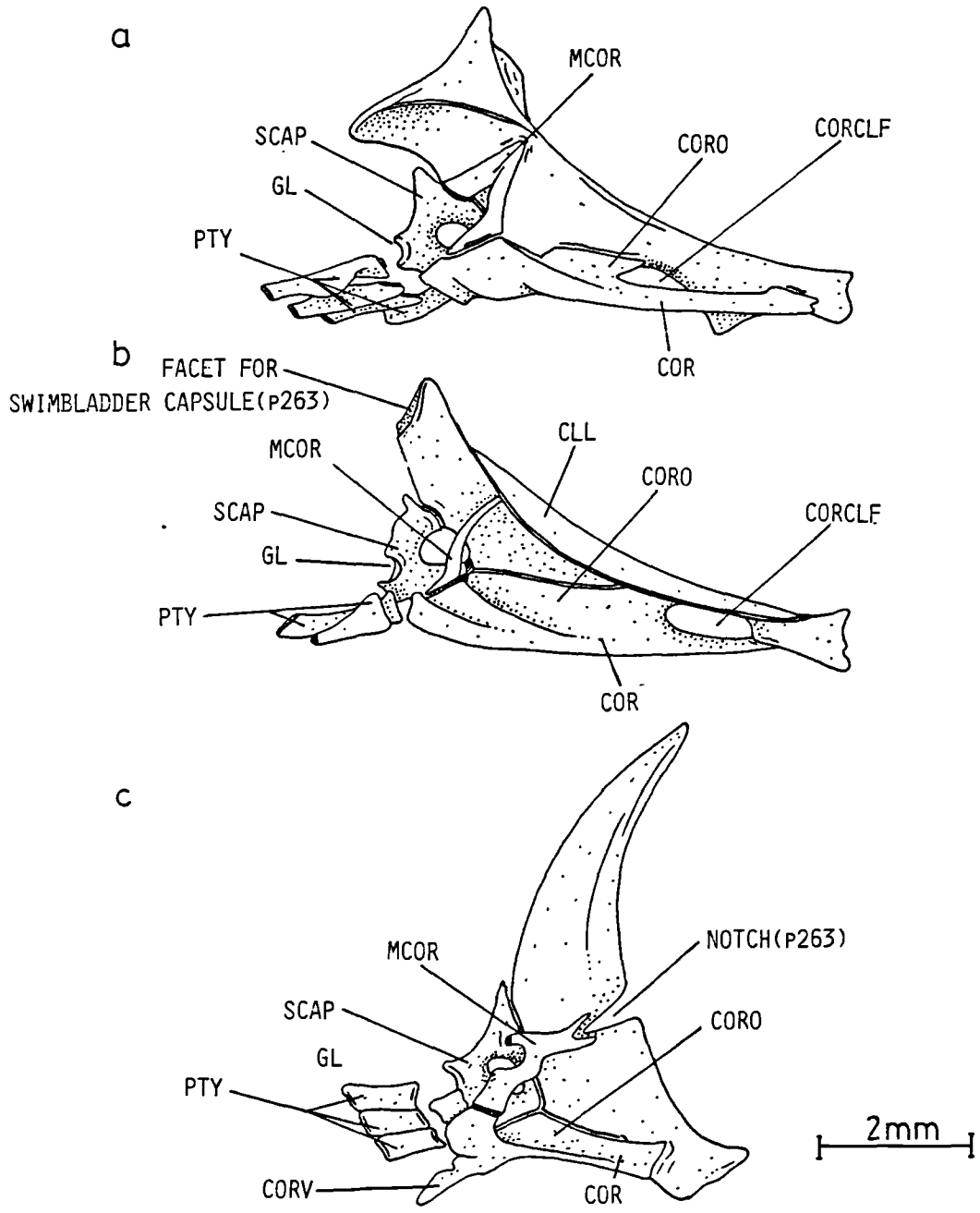

a
MCOR
SCAP
GL
PTY
CORO
CORCLF
COR
b
FACET FOR
SWIMBLADDER CAPSULE(p263)
MCOR
SCAP
GL
PTY
CLL
CORO
CORCLF
COR
c
MCOR
SCAP
GL
PTY
CORV
NOTCH(p263)
CORO
COR
2mm

Fig. Lxv Pectoral skeleton

a. Acanthopsis choirorhynchus (medial view left)

b. Botia almorhae (lateral view right)

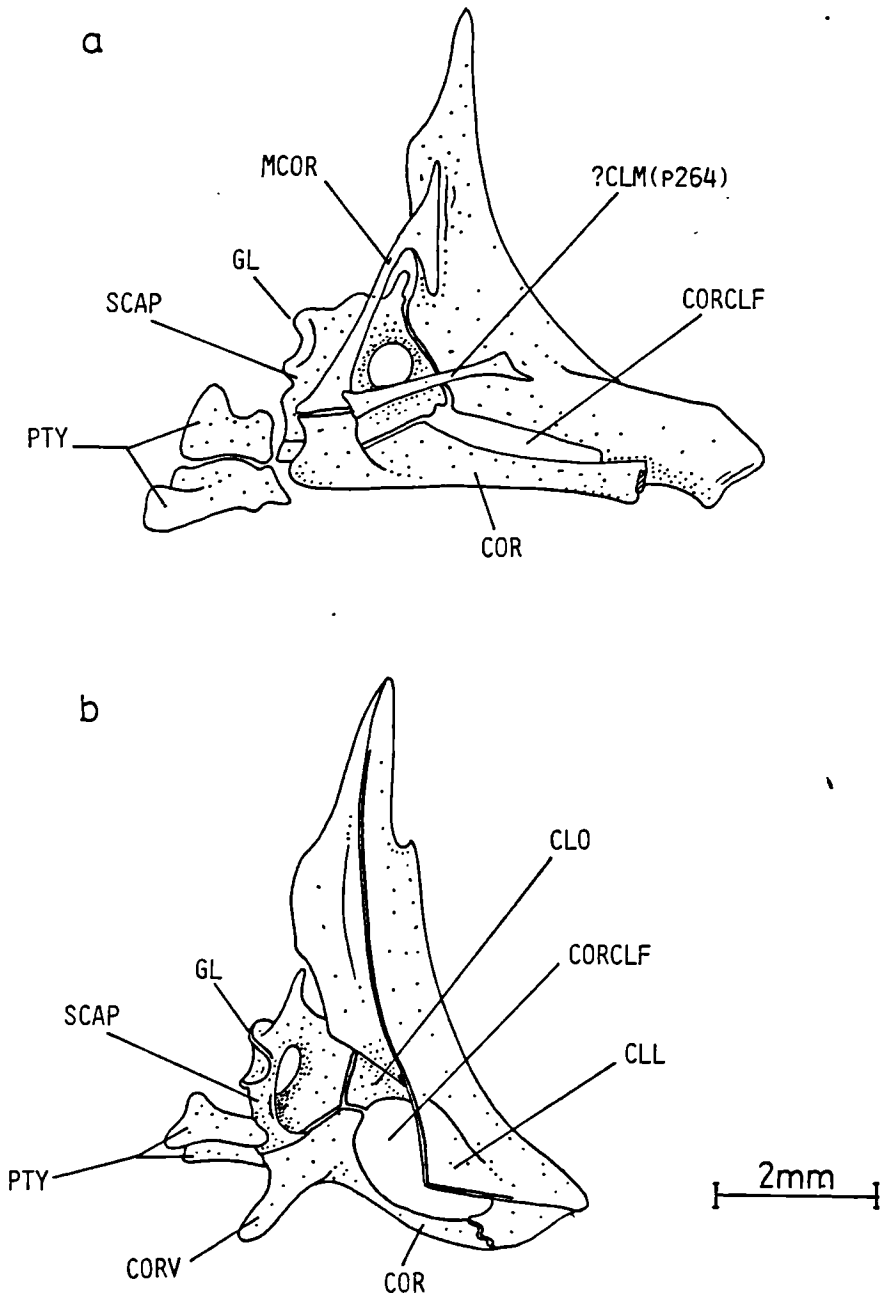

a
MCOR
?CLM(P264)
GL
SCAP
CORCLF
PTY
COR
b
CLO
CORCLF
GL
SCAP
CLL
PTY
CORV
COR
2mm

Fig. Lxvi Pectoral skeleton

a. Lepidocephalus guntea (medial view right ♂)

b. Misgurnus anguillicaudatus (dorsal view right fin articulation)

c. Acanthophthalmus semicinctus (dorsal view right fin articulation)

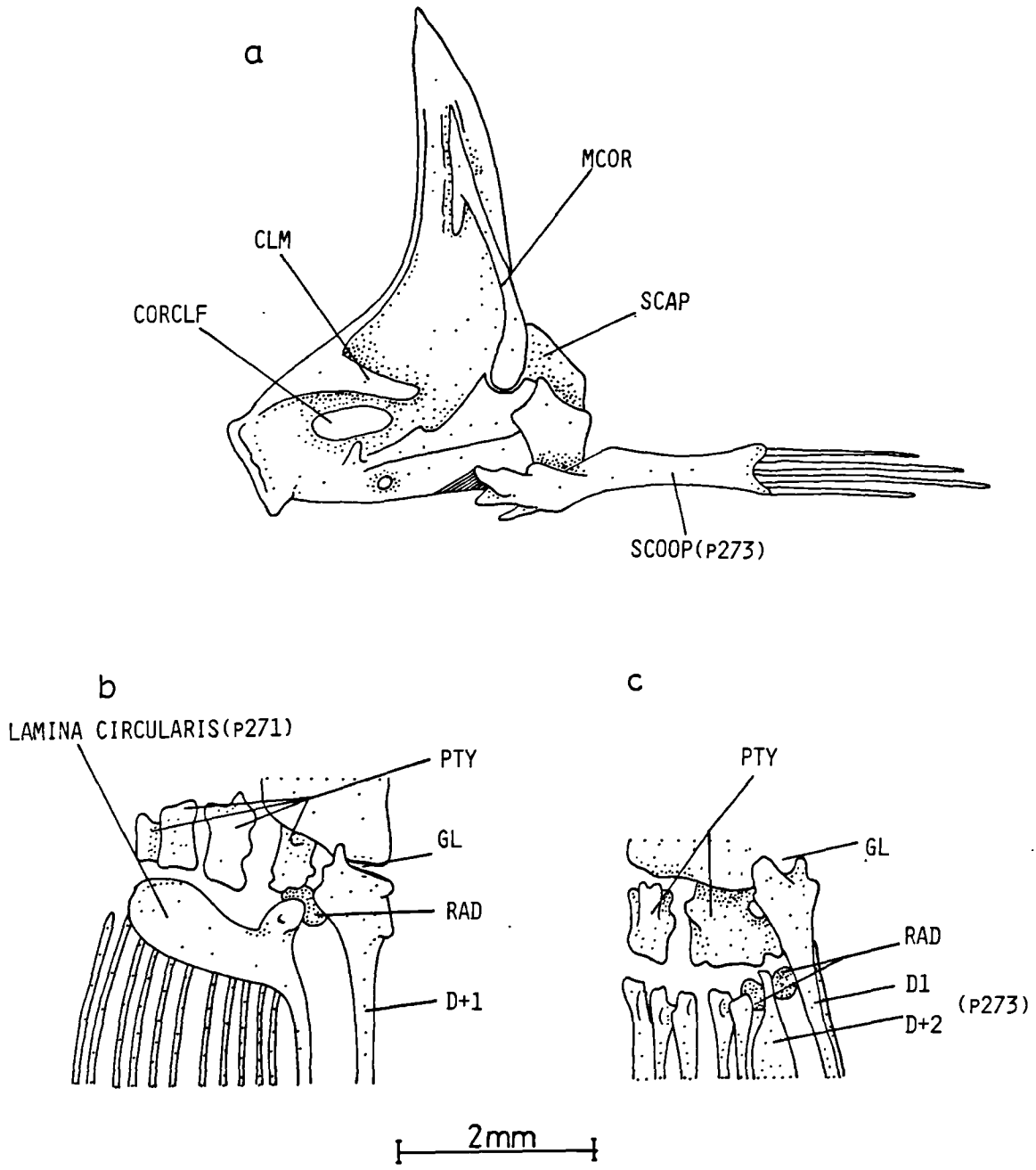

a
MCOR
CLM
SCAP
CORCLF
SCOOP(P273)
b
LAMINA CIRCULARIS(P271)
PTY
GL
RAD
D+1
c
PTY
GL
RAD
D1
(P273)
D+2
2mm

Fig. Lxvii Right pelvic skeleton (Ventral view)

a. Orthrias tschaiyssuensis

b. Noemacheilus strauchi

c. Glaniopsis hanitschi

d. Homaloptera

e. Gastromyzon

f. Acanthophthalmus

g. Botia hymenophysa

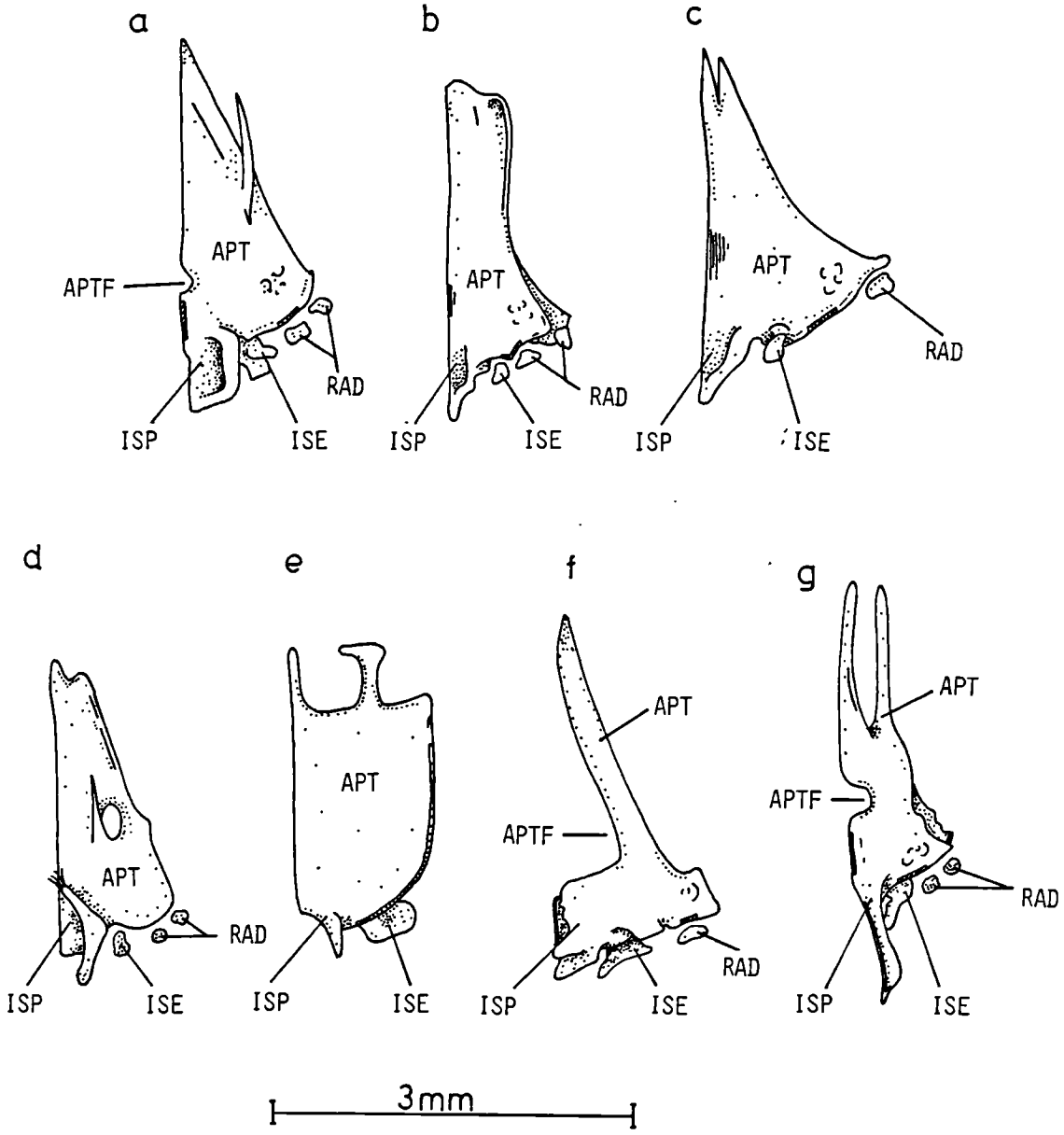

a
b
c
APT
APTF
RAD
ISP
ISE
d
e
f
g
3mm

Fig. Lxviii Caudal skeleton (left lateral view)

a. Noemacheilus denisoni

b. Oronectes platycephalus

c. Somileptes gongota

d. Lepidocephalus annandali

e. Leptobotia fasciata

f. Botia almorhae

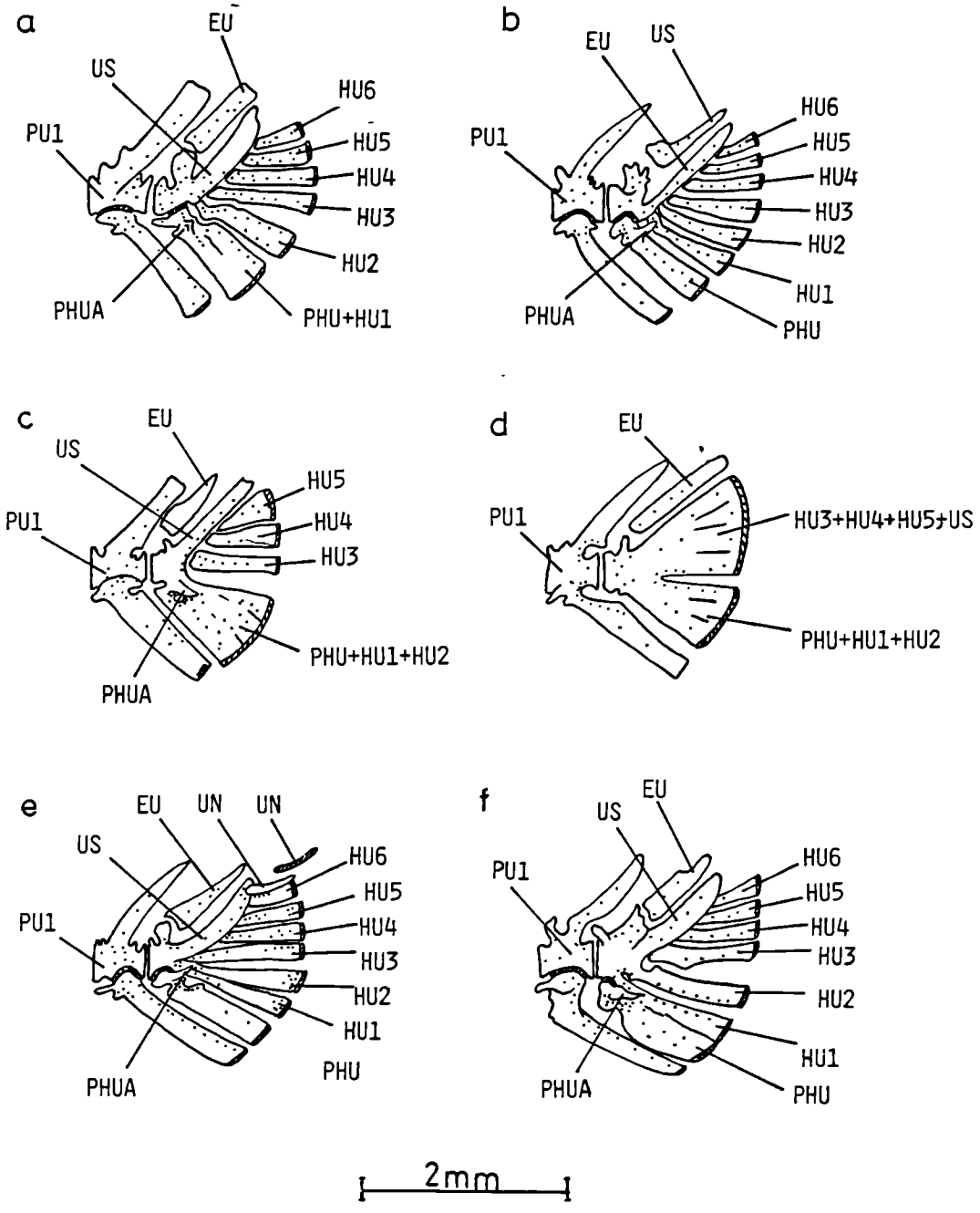

a
EU
US
HU6
PU1
HU5
HU4
HU3
HU2
PHUA
PHU+HU1
b
EU
US
HU6
PU1
HU5
HU4
HU3
HU2
HU1
PHUA
PHU
c
EU
US
HU5
PU1
HU4
HU3
PHU+HU1+HU2
PHUA
d
EU
PU1
HU3+HU4+HU5+US
PHU+HU1+HU2
e
EU
UN
UN
US
HU6
HU5
PU1
HU4
HU3
HU2
HU1
PHU
PHUA
f
EU
US
HU6
PU1
HU5
HU4
HU3
HU2
HU1
PHUA
PHU
2mm

Fig. Lxix Ossification associated with V1-4 in *Noemacheilus fasciata*

a. Left lateral view

b. Ventral view

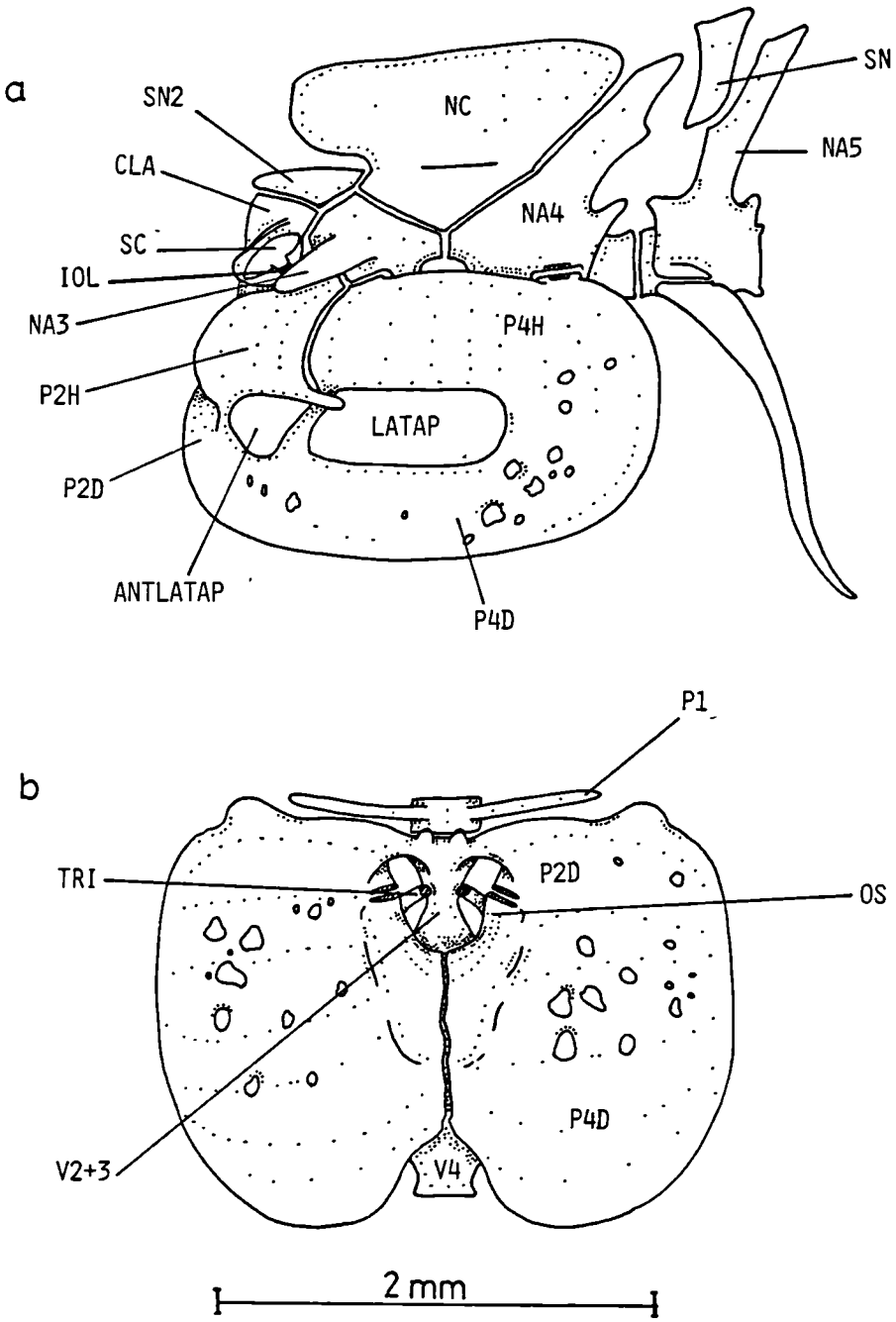

a
SN2
NC
SN
CLA
NA5
NA4
SC
IOL
NA3
P4H
P2H
LATAP
P2D
ANTLATAP
P4D
b
P1
TRI
P2D
OS
P4D
V2+3
V4
2 mm

Fig. Lxx Ossification associated with V1-4 in *Glaniopsis hanitschi*

a. Left lateral view

b. Ventral view

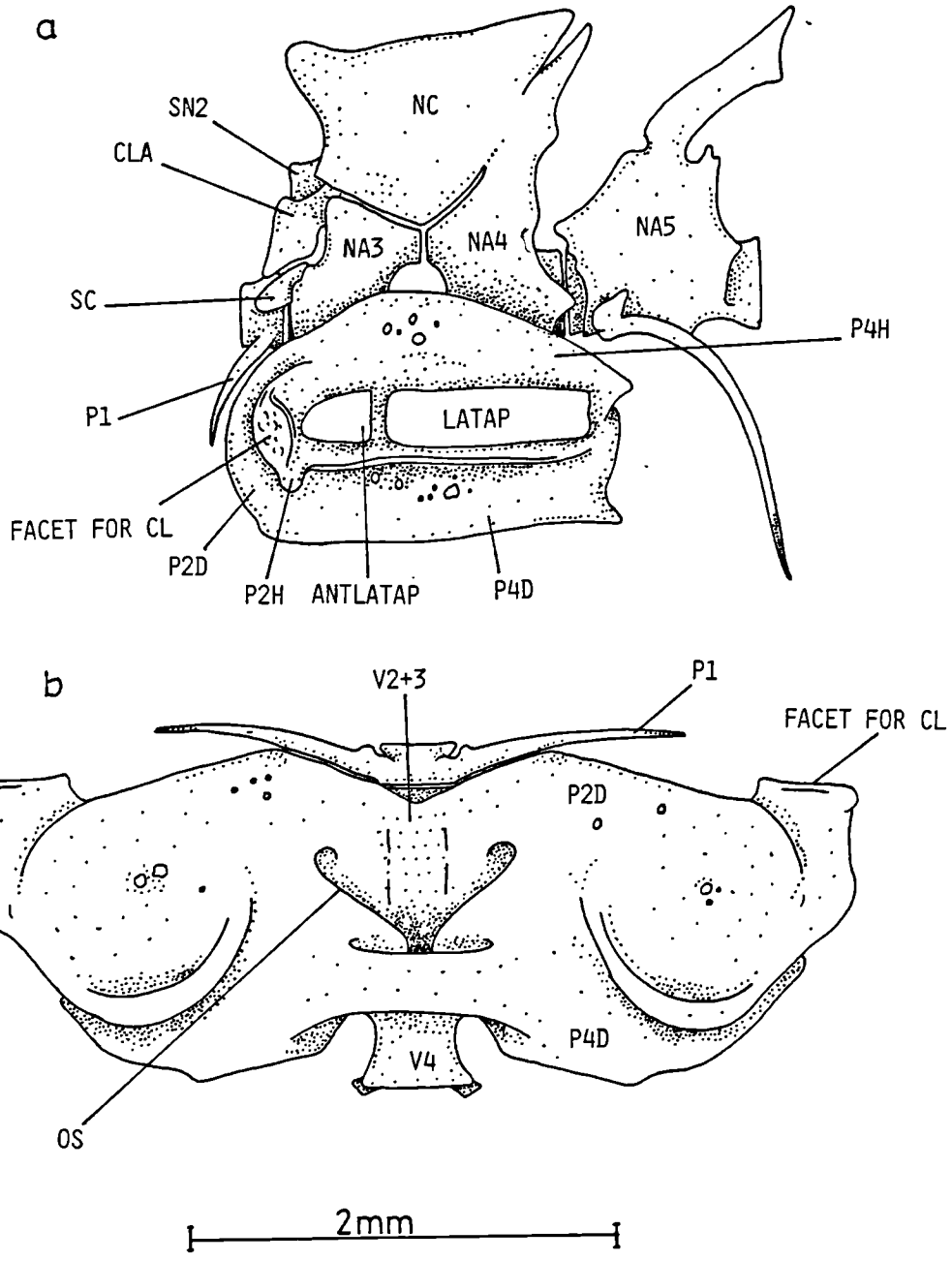

a
SN2
NC
CLA
NA3
NA4
NA5
SC
P4H
P1
LATAP
FACET FOR CL
P2D
P2H
ANTLATAP
P4D
b
V2+3
P1
FACET FOR CL
P2D
P4D
V4
OS
2mm

Fig. Lxxi Ossification associated with V1-4 in Gastromyzon borneensis

a. Left lateral view

b. Ventral view

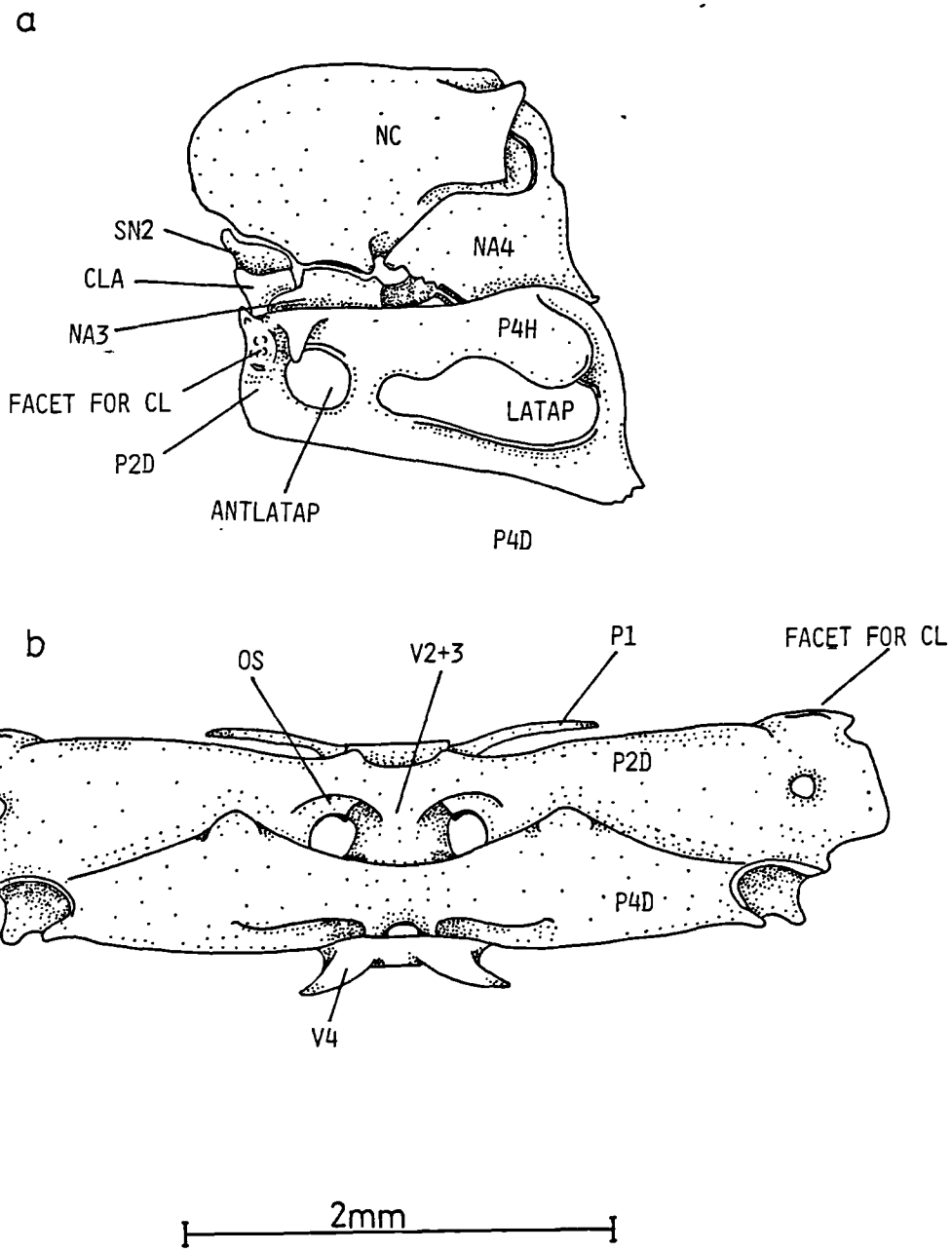

a
NC
SN2
NA4
CLA
NA3
P4H
FACET FOR CL
LATAP
P2D
ANTLATAP
P4D
b
OS
V2+3
P1
FACET FOR CL
P2D
P4D
V4
2mm

Fig. Lxxii Ossification associated with V1-4 in

Homaloptera orthagoniata

a. Left lateral view

b. Ventral view

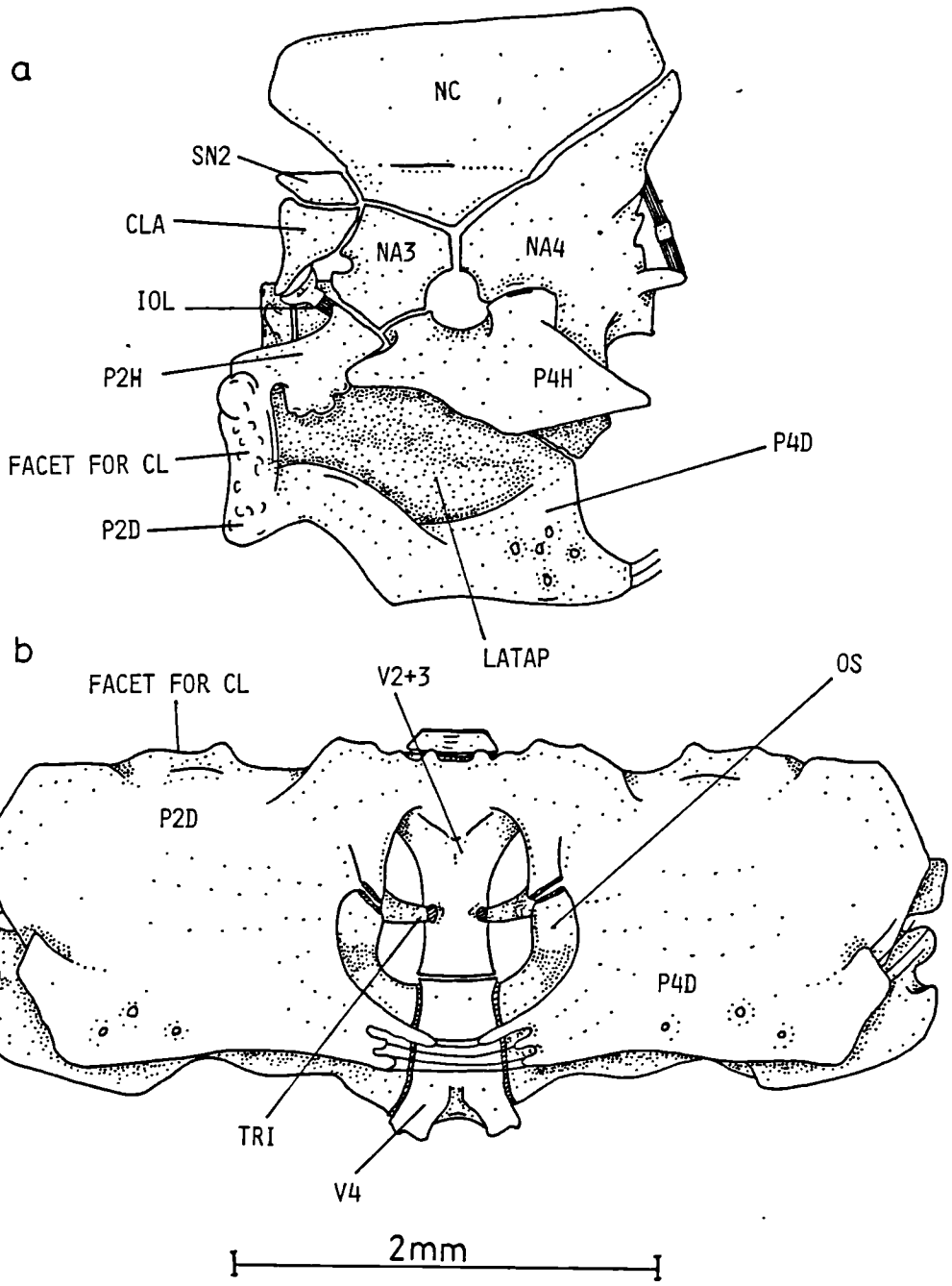

a
NC
SN2
CLA
NA3
NA4
IOL
P2H
P4H
FACET FOR CL
P4D
P2D
LATAP
b
FACET FOR CL
V2+3
OS
P2D
P4D
TRI
V4
2mm

Fig. Lxxiii Ossification associated with V1-4 in Cobitini (Left lateral view)

a. Misgurnus anguillicaudatus

b. Lepidocephalus caudofurcatus

c. Somileptes gongota

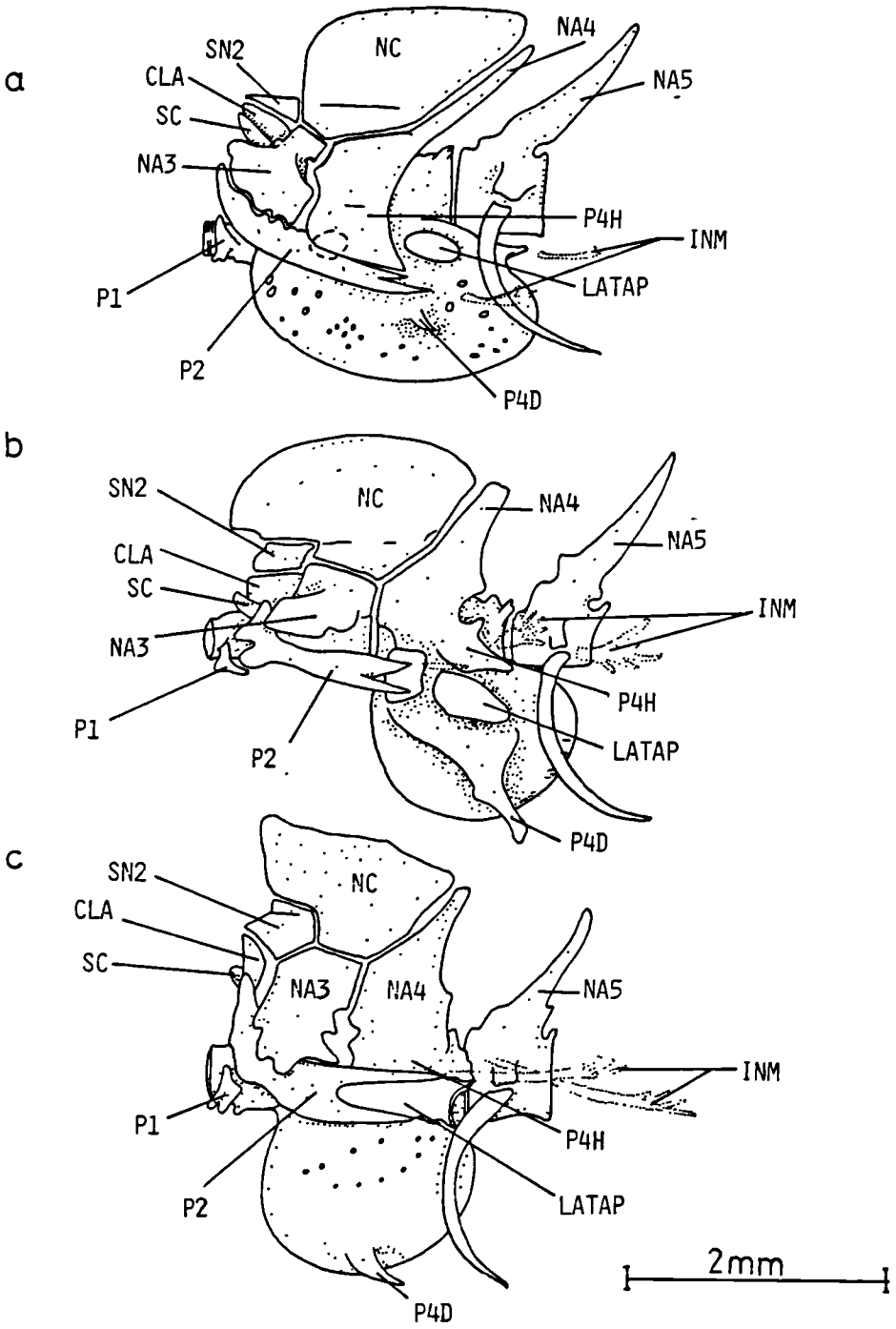

a
SN2
NC
NA4
CLA
NA5
SC
NA3
P4H
INM
LATAP
P1
P2
P4D
b
SN2
NC
NA4
NA5
CLA
SC
INM
NA3
P4H
P1
LATAP
P2
P4D
c
SN2
NC
CLA
SC
NA3
NA4
NA5
INM
P1
P4H
P2
LATAP
2mm
P4D

Fig. Lxxiv Ossification associated with V1-4 in *Leptobotia elongata*

a. Left lateral view

b. Ventral view

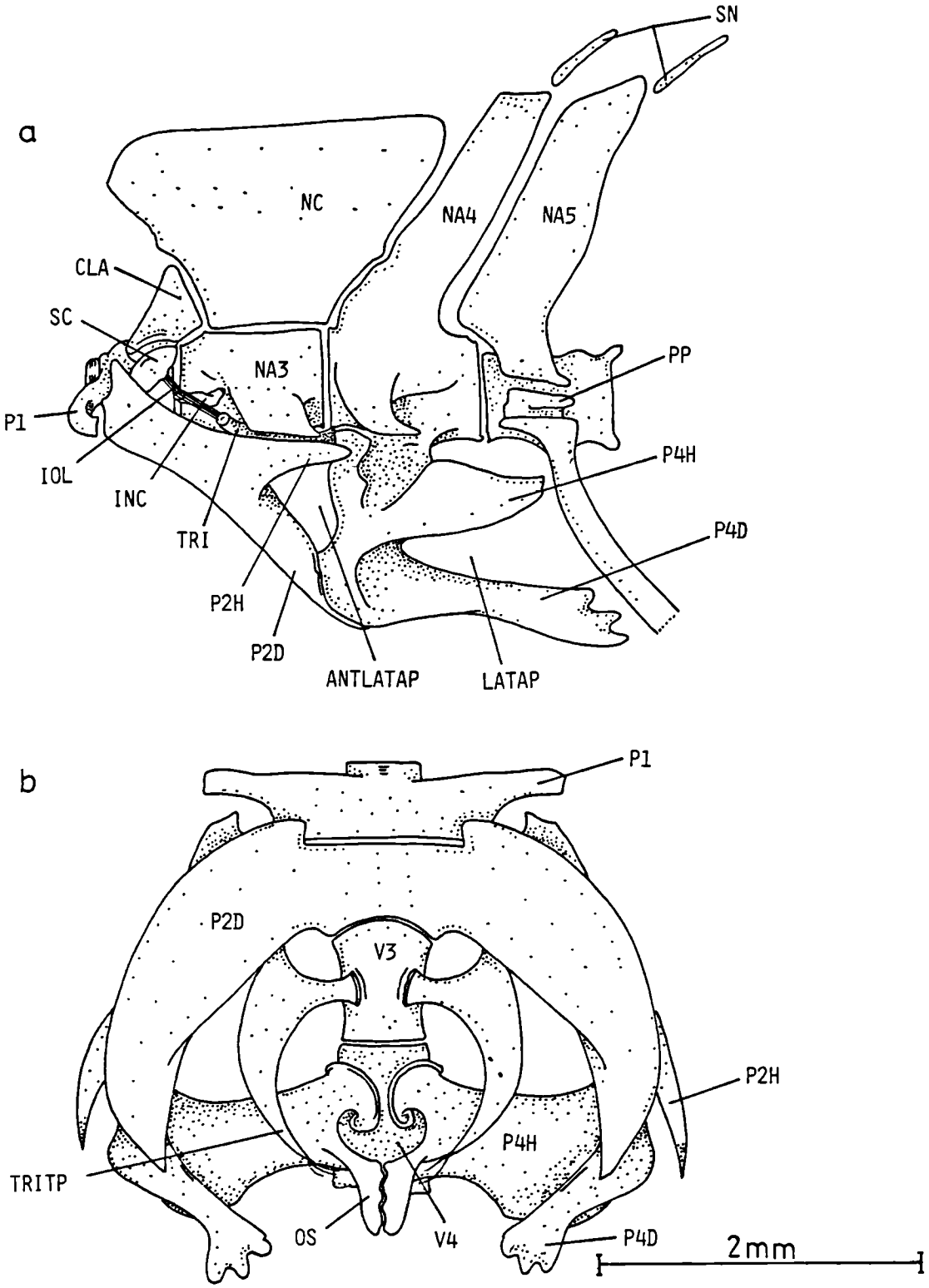

a
SN
NC
NA4
NA5
CLA
SC
NA3
PP
P1
P4H
IOL
INC
TRI
P4D
P2H
P2D
ANTLATAP
LATAP
b
P1
P2D
V3
P2H
P4H
TRITP
OS
V4
P4D
2mm

Fig. Lxxv Ossification associated with V1-4 in *Botia hymenophysa*

a. Left lateral view

b. Ventral view

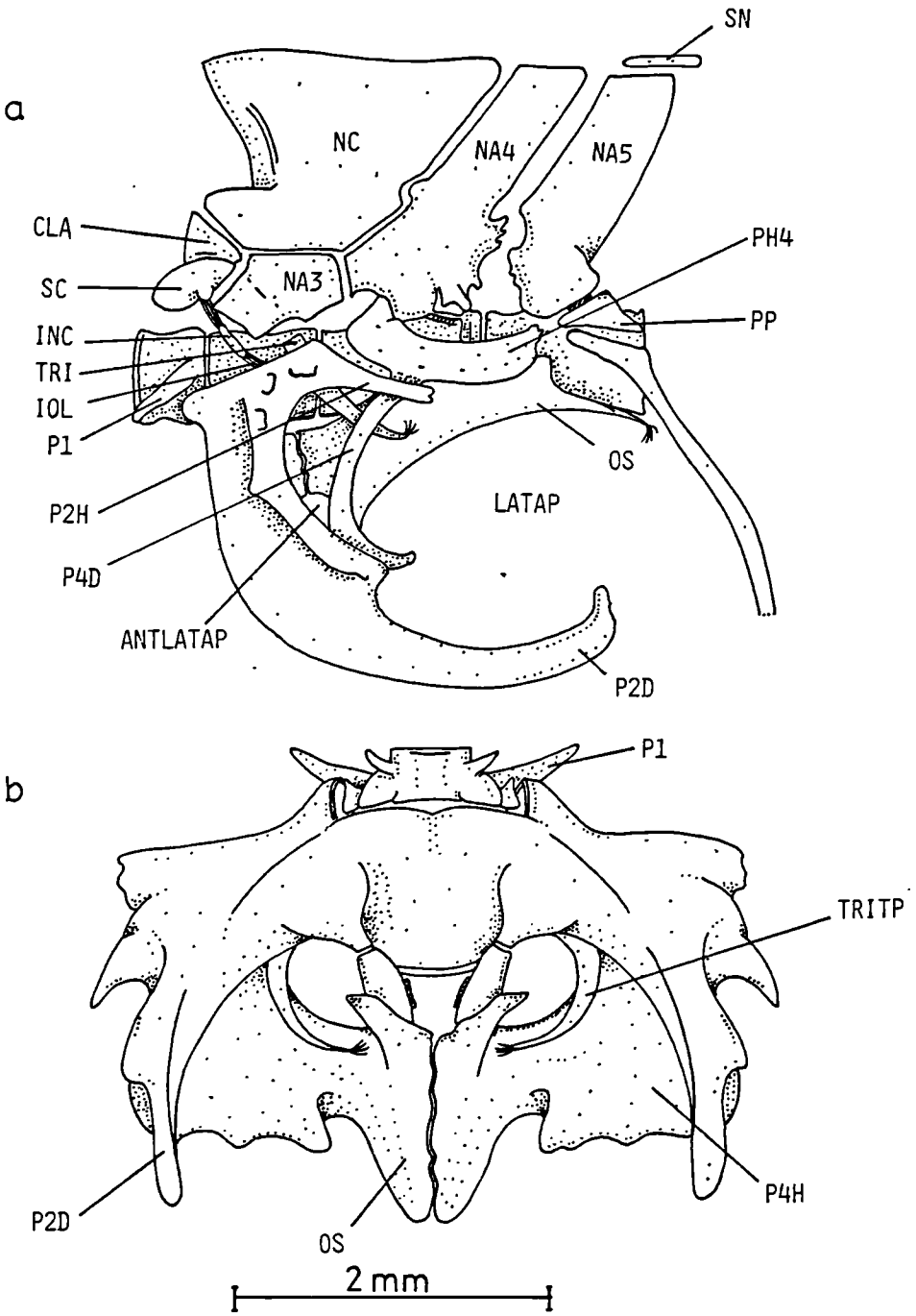

a
SN
NC
NA4
NA5
CLA
PH4
SC
NA3
PP
INC
TRI
IOL
P1
OS
LATAP
P2H
P4D
ANTLATAP
P2D
b
P1
TRITP
P2D
OS
P4H
2 mm

Fig. Lxxvi Ossification associated with V1-4 in *Botia almorhae*

a. Left lateral view

b. Ventral view

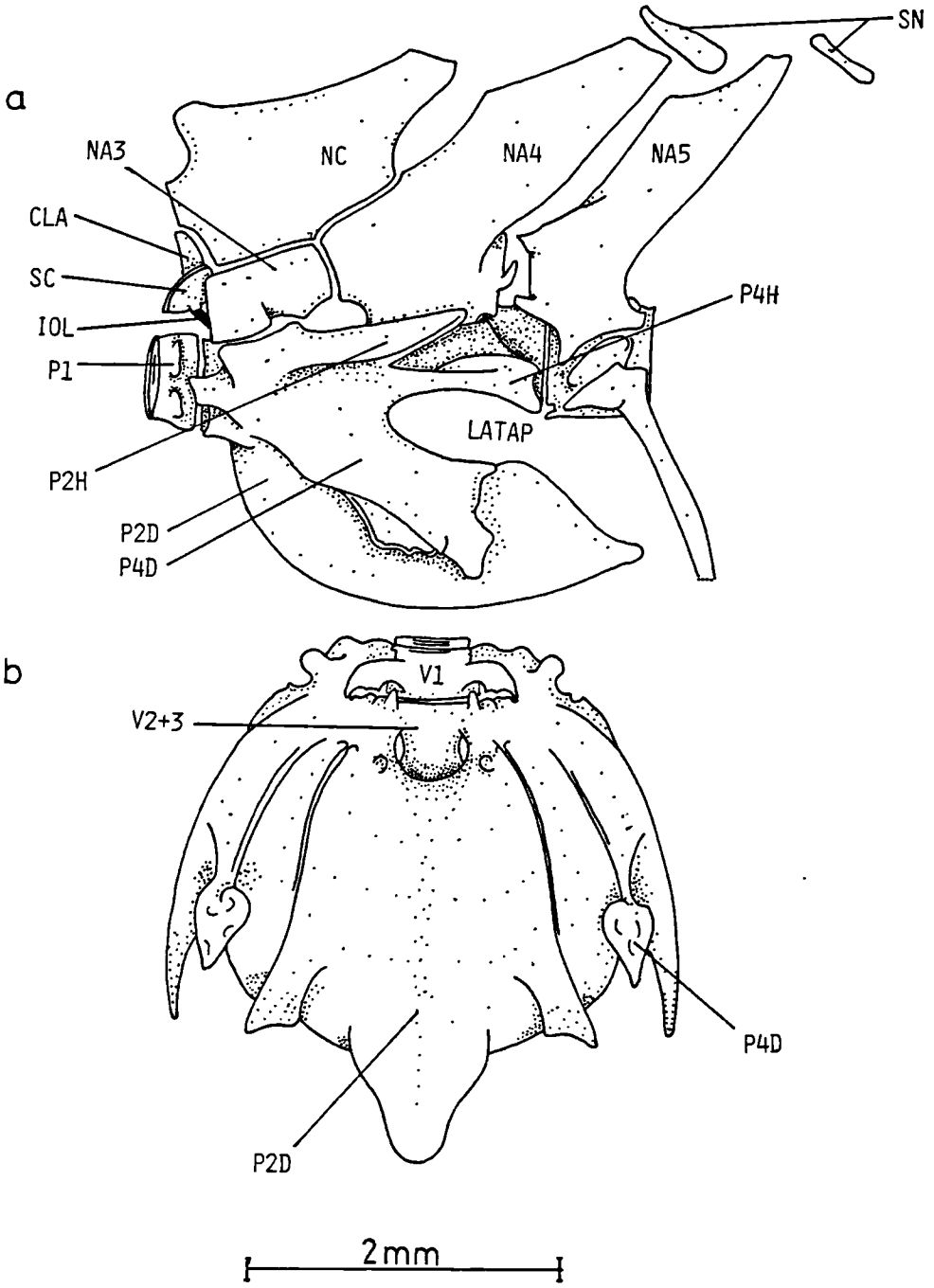

a
SN
NA3
NC
NA4
NA5
CLA
SC
IOL
P1
P4H
LATAP
P2H
P2D
P4D
b
V1
V2+3
P4D
P2D
2mm

Fig. Lxxvii Ossification associated with V1-4 in *Saurogobio dabryi*

a. Left lateral view

b. Ventral view

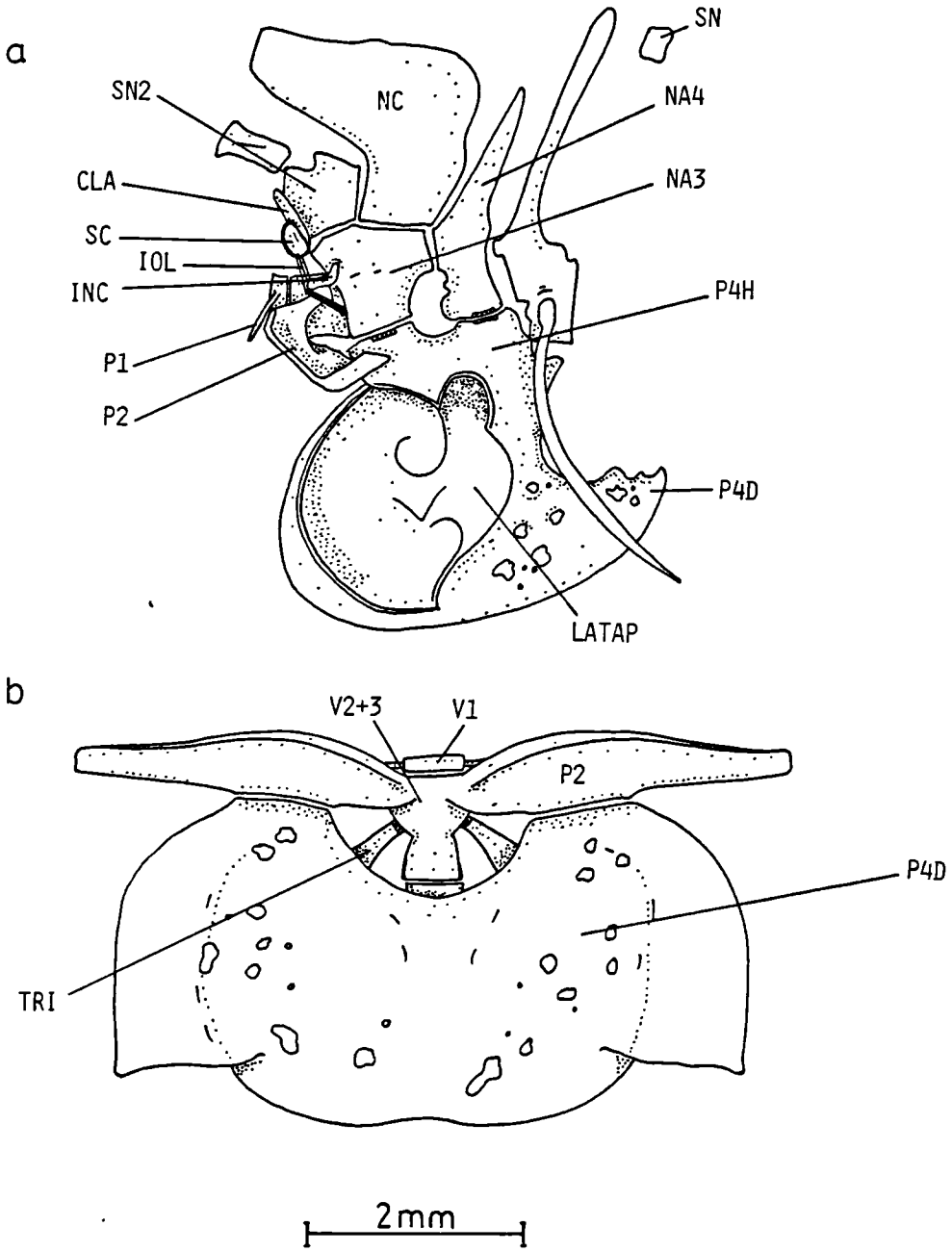

a
SN
SN2
NC
NA4
CLA
NA3
SC
IOL
INC
P4H
P1
P2
P4D
LATAP
b
V2+3
V1
P2
P4D
TRI
2mm

Fig. Lxxviii Ossification associated with V1-4 in *Catostomus catostomus* (Posterior view)

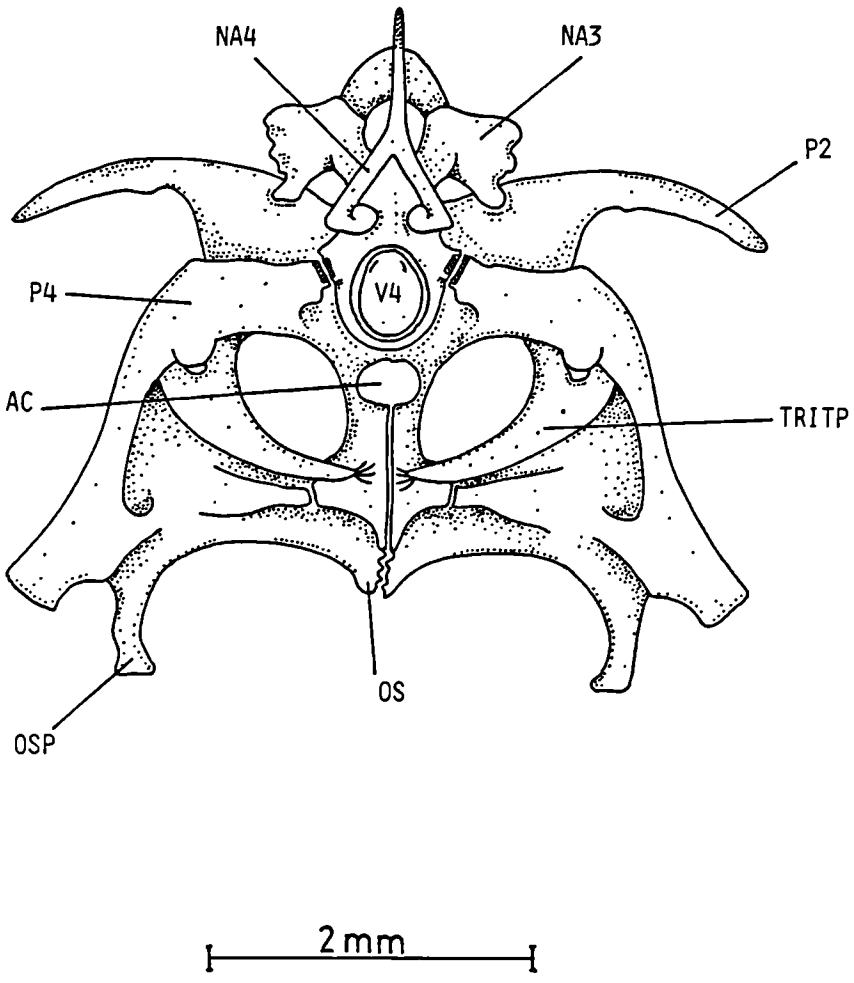

NA4
NA3
P2
P4
V4
AC
TRITP
OS
OSP
2 mm

Fig. Lxxix Ossification associated with V1-4 in *Gyrinocheilus aymonieri*

a. Left lateral view

b. Ventral view

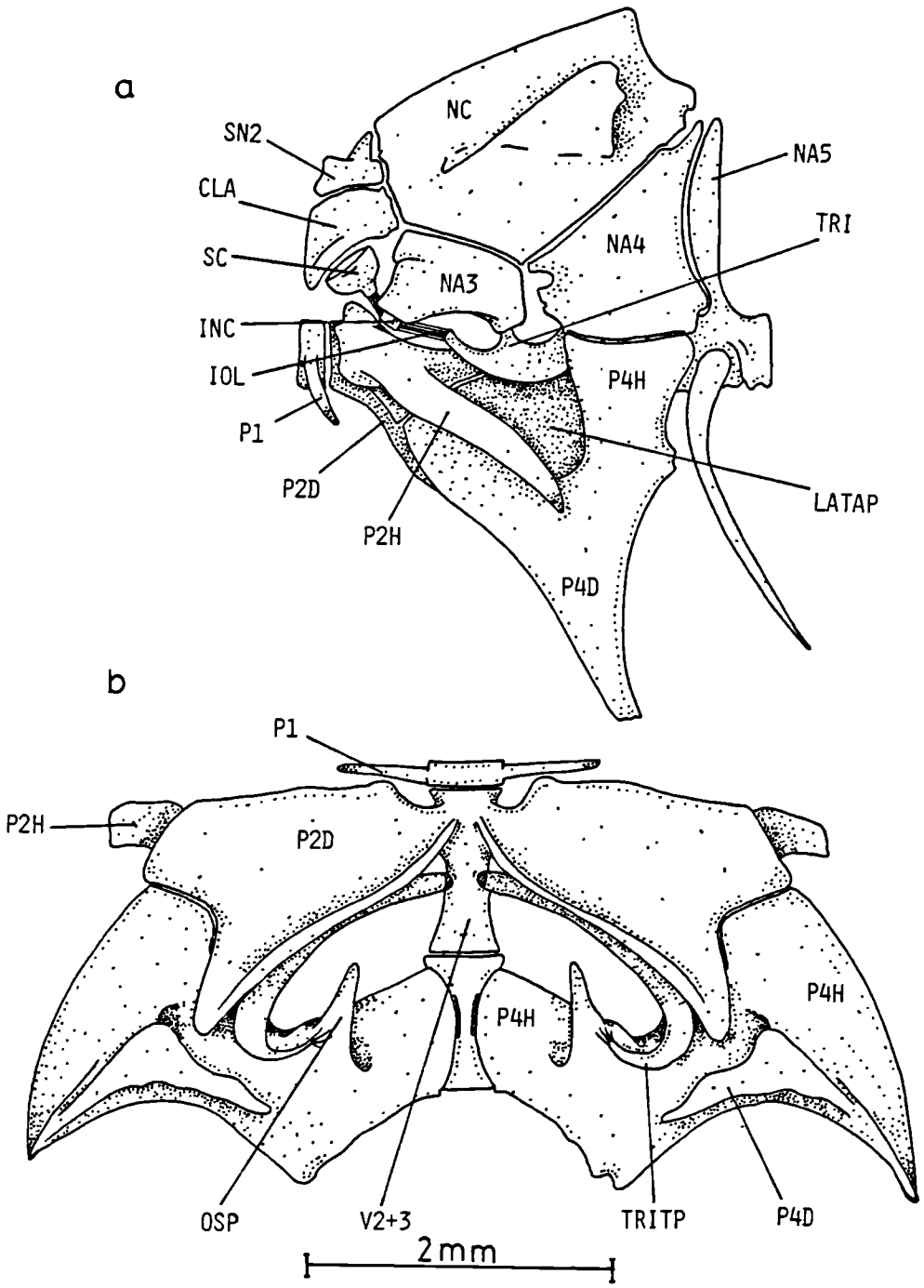

a
NC
SN2
CLA
SC
INC
IOL
P1
P2D
P2H
NA3
NA4
NA5
TRI
P4H
LATAP
P4D
b
P1
P2H
P2D
P4H
P4H
OSP
V2+3
TRITP
P4D
2mm

Fig. Lxxx Ossification associated with V1-4 in *Psilorhynchus balitora*

a. Left lateral view

b. Ventral view

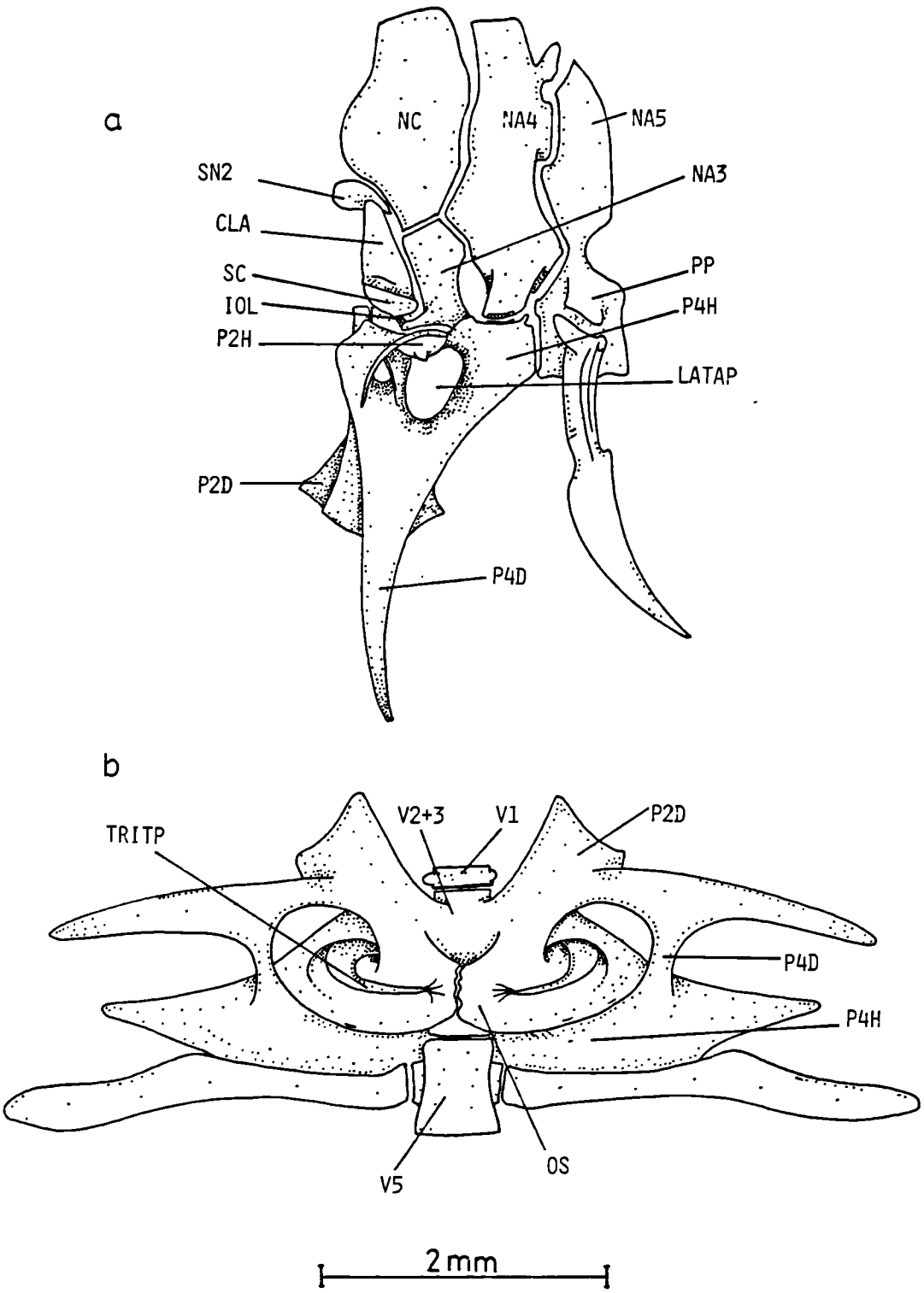

a
NC
NA4
NA5
SN2
NA3
CLA
SC
PP
IOL
P4H
P2H
LATAP
P2D
P4D
b
TRITP
V2+3
V1
P2D
P4D
P4H
V5
OS
2 mm

Fig. Lxxxi Ossification associated with V1-4 in *Rhamphichthys rostratus*

a. Left lateral view

b. Ventral view

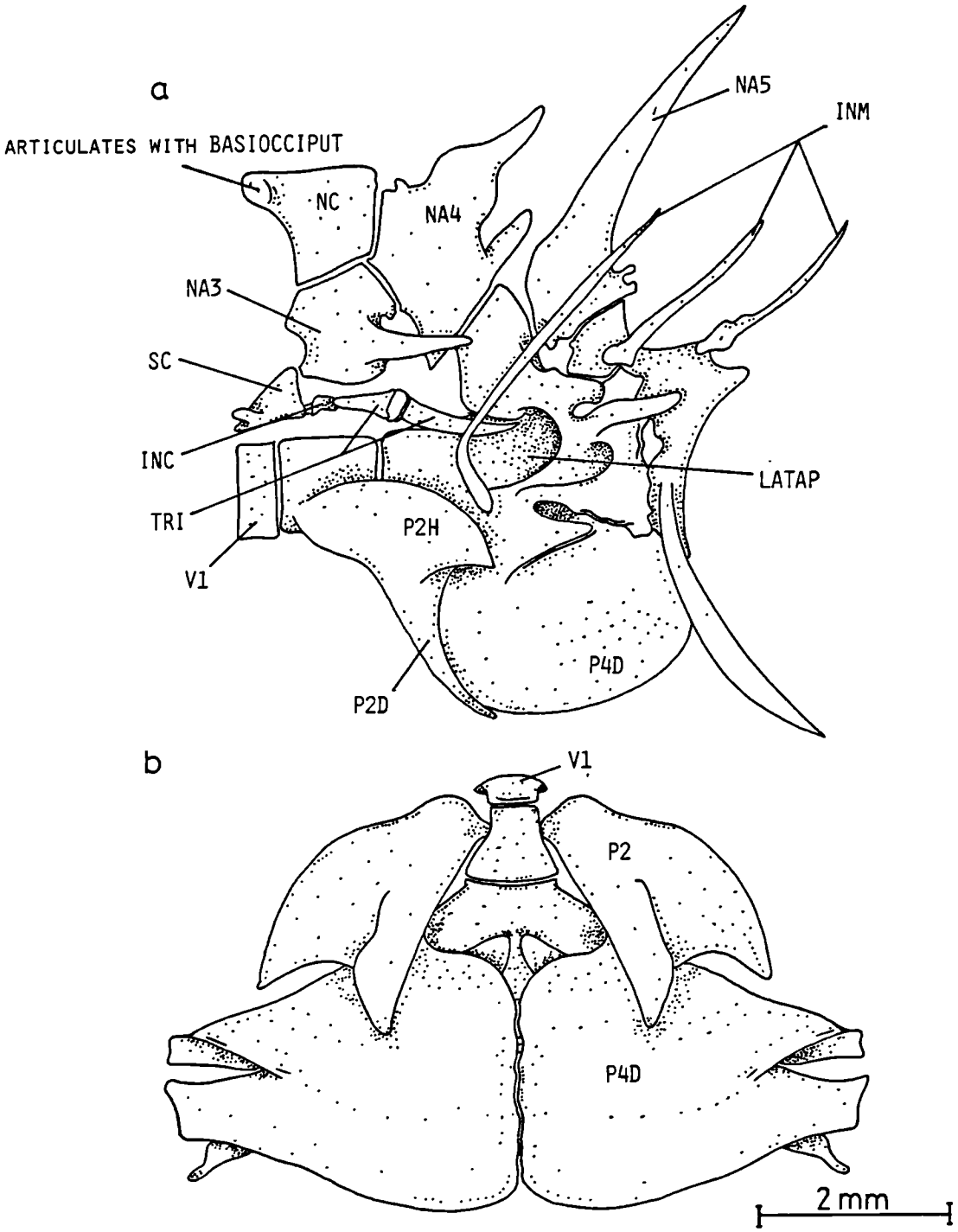

a
ARTICULATES WITH BASIOCCIPUT
NC
NA4
NA5
INM
NA3
SC
INC
TRI
V1
P2H
LATAP
P4D
P2D
b
V1
P2
P4D
2 mm

Fig. Lxxxii Branching diagram showing hypothesis of cobitoid interrelationships based on characters of ossification associated with V1-4.

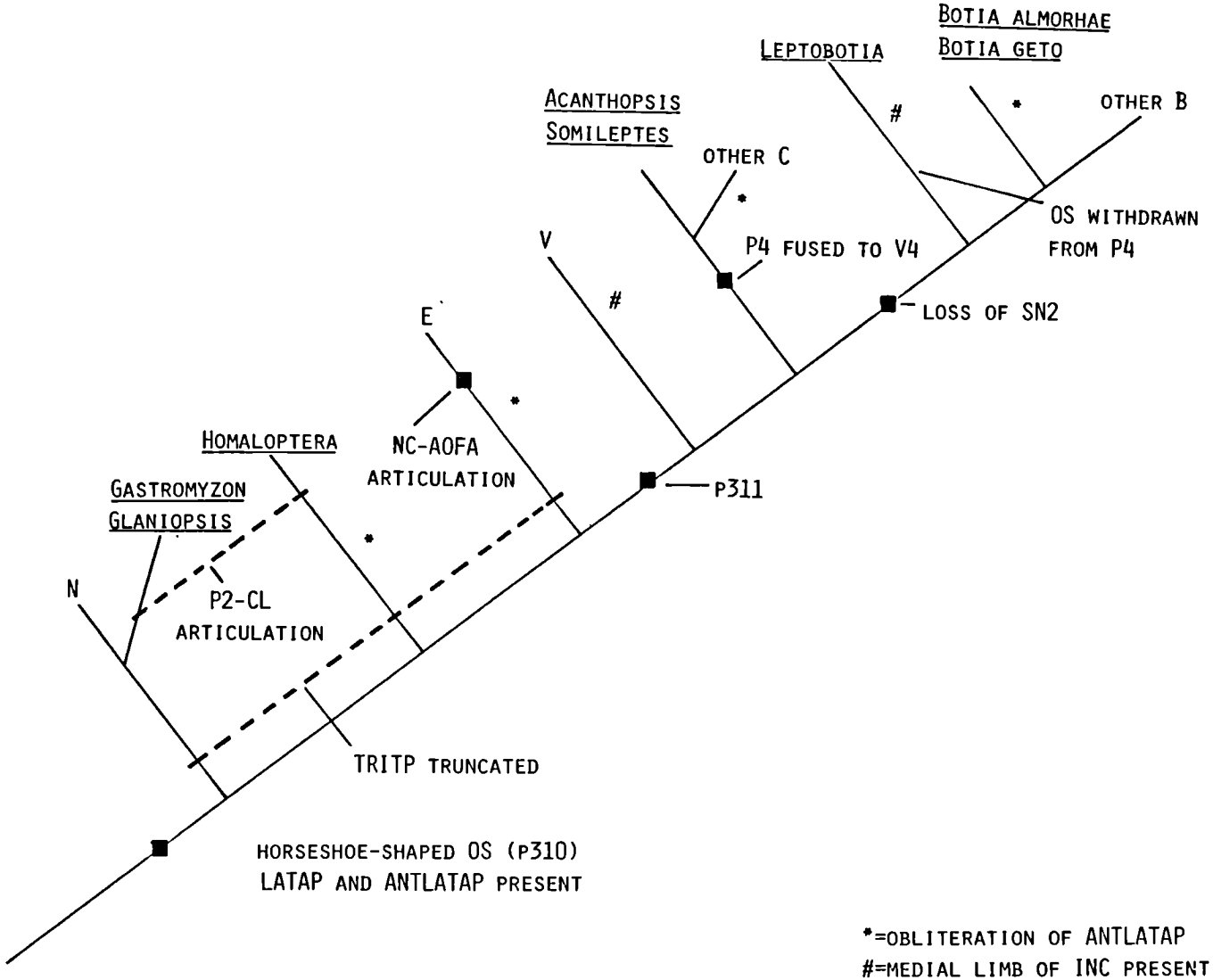

BOTIA ALMORHAE
BOTIA GETO
LEPTOBOTIA
OTHER B
ACANTHOPSIS
SOMILEPTES
OTHER C
OS WITHDRAWN
FROM P4
P4 FUSED TO V4
V
E
LOSS OF SN2
HOMALOPTERA
NC-AOFA
ARTICULATION
P311
GASTROMYZON
GLANIOPSIS
N
P2-CL
ARTICULATION
TRITP TRUNCATED
HORSESHOE-SHAPED OS (P310)
LATAP AND ANTLATAP PRESENT
*=OBLITERATION OF ANTLATAP
#=MEDIAL LIMB OF INC PRESENT

Fig. Lxxxiii Sublingual ossification (Hypohyal region in ventral view)

a. Noemacheilus botia

b. Ellopostoma

c. Homaloptera

d. Lepidocephalus annandali

e. Lepidocephalus guntea

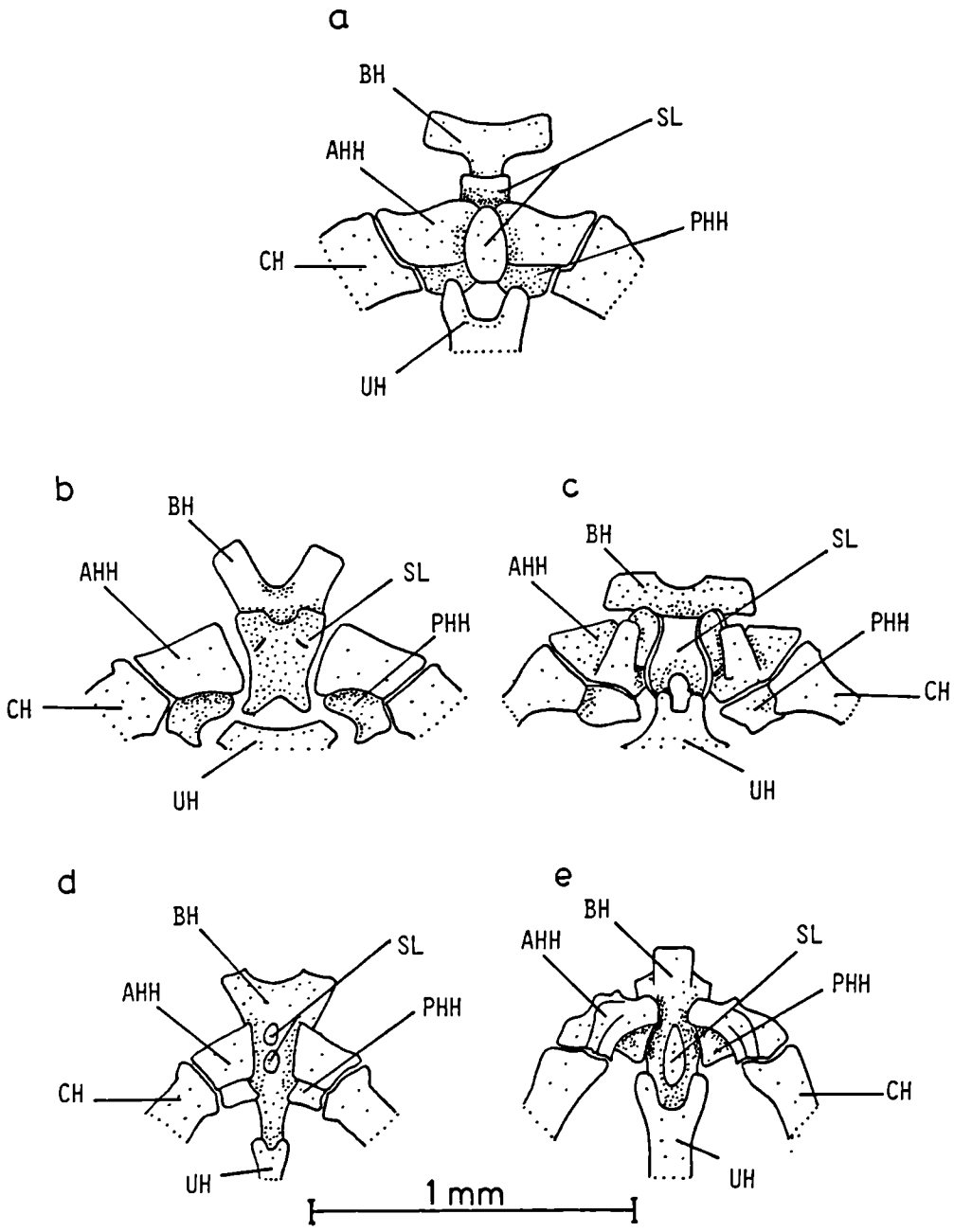

a
BH
SL
AHH
PHH
CH
UH
b
BH
AHH
SL
PHH
CH
UH
c
BH
SL
AHH
PHH
CH
UH
d
BH
SL
AHH
PHH
CH
UH
e
BH
AHH
SL
PHH
CH
UH
1 mm

Fig. Lxxxiv Hyoid skeleton [Ventral view]

a. Botia modesta

b. Botia almorhae

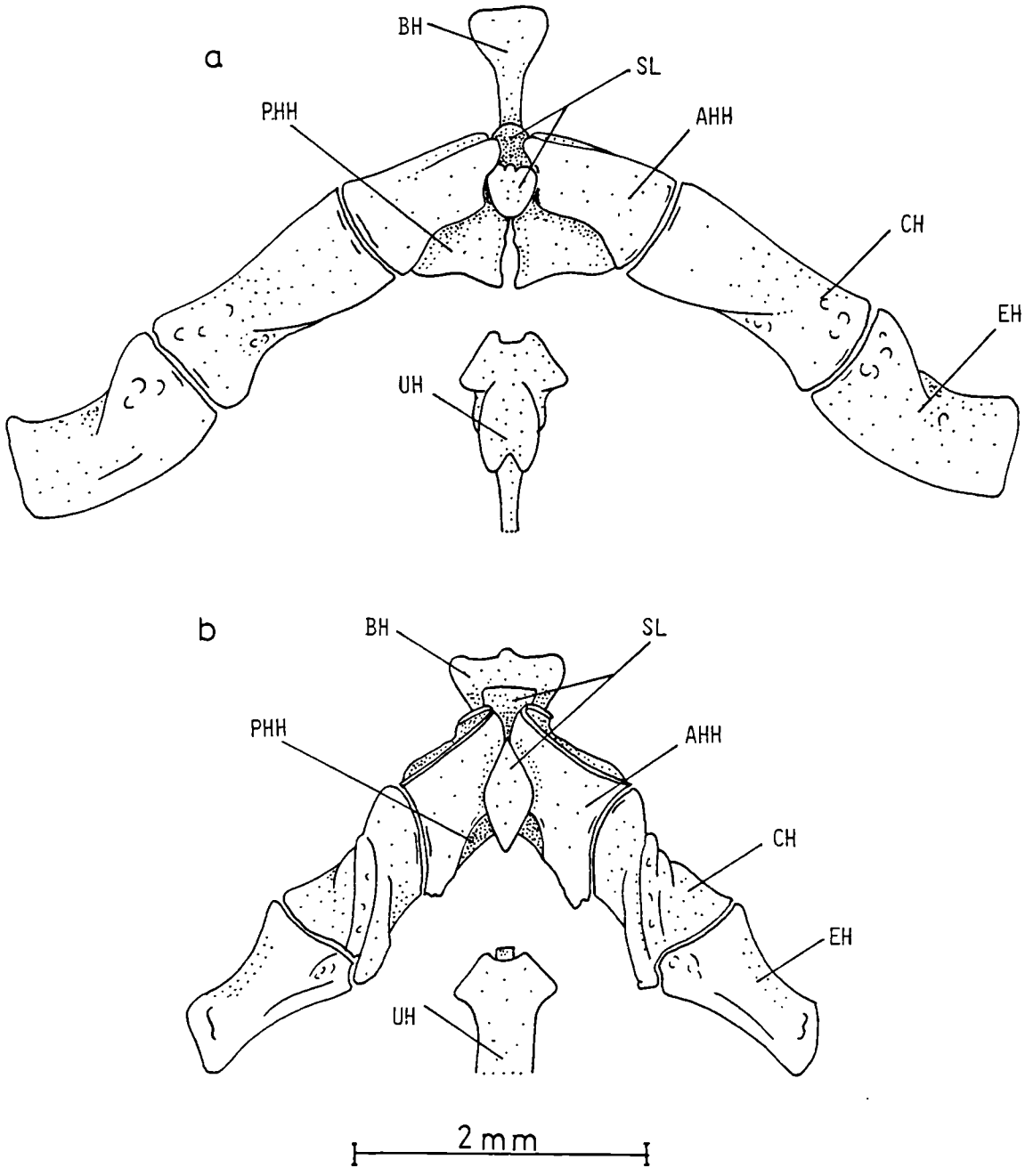

a
BH
SL
PHH
AHH
CH
EH
UH
b
BH
SL
PHH
AHH
CH
EH
UH
2 mm

Fig. Lxxxv Basibranchial skeleton (Dorsal view)

a. Ellopostoma

b. Somileptes gongota

c. Acanthophthalmus

d. Botia modesta

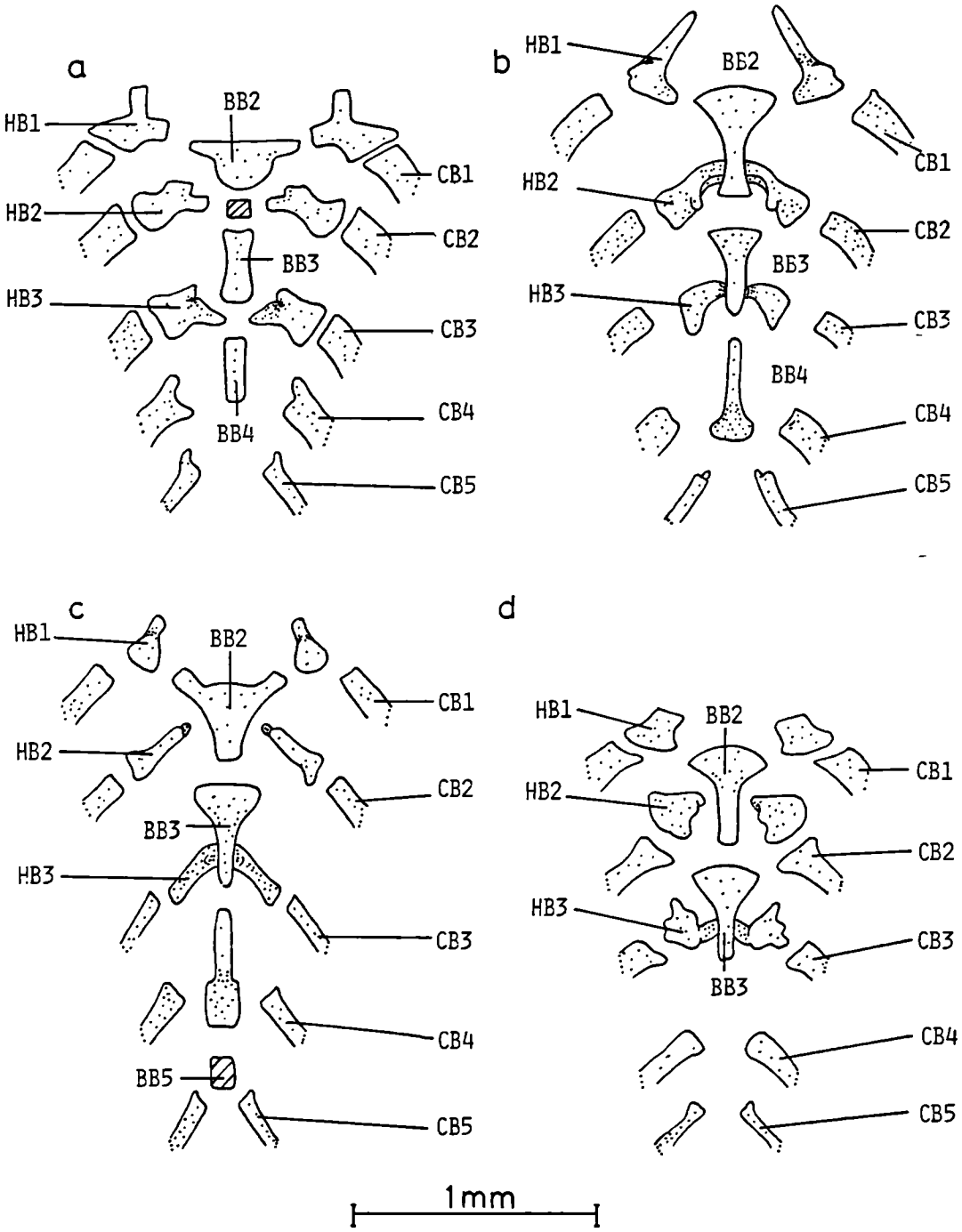

a
HB1
BB2
CB1
HB2
CB2
BB3
HB3
CB3
CB4
BB4
CB5
b
HB1
BB2
CB1
HB2
CB2
BB3
HB3
CB3
BB4
CB4
CB5
c
HB1
BB2
CB1
HB2
CB2
BB3
HB3
CB3
CB4
BB5
CB5
d
HB1
BB2
CB1
HB2
CB2
HB3
CB3
BB3
CB4
CB5
1mm

Fig. Lxxxvi Branching diagram showing hypothesis of relationship between cobitoids, Catostomus and Gyrinocheilus, based on branchial characters, proposed by Mayden (pers. comm.)

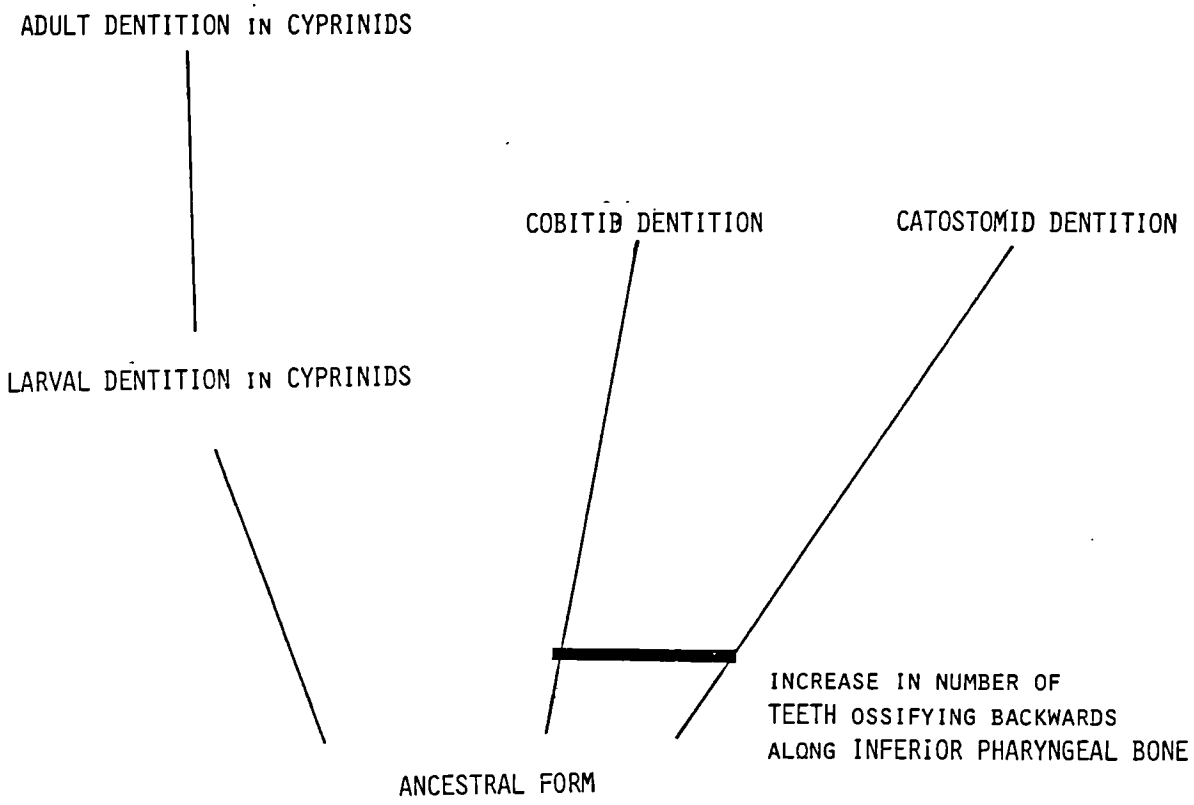

ADULT DENTITION IN CYPRINIDS
LARVAL DENTITION IN CYPRINIDS
COBITID DENTITION
CATOSTOMID DENTITION
INCREASE IN NUMBER OF
TEETH OSSIFYING BACKWARDS
ALONG INFERIOR PHARYNGEAL BONE
ANCESTRAL FORM

Fig. Lxxxvii Left epibranchial skeleton [dorsal lateral view]

a. Noemacheilus yarkandensis

b. Ellopostoma

c. Somileptes gongota

d. Botia modesta

e. Catostomus catostomus

f. Gyrinocheilus aymonieri

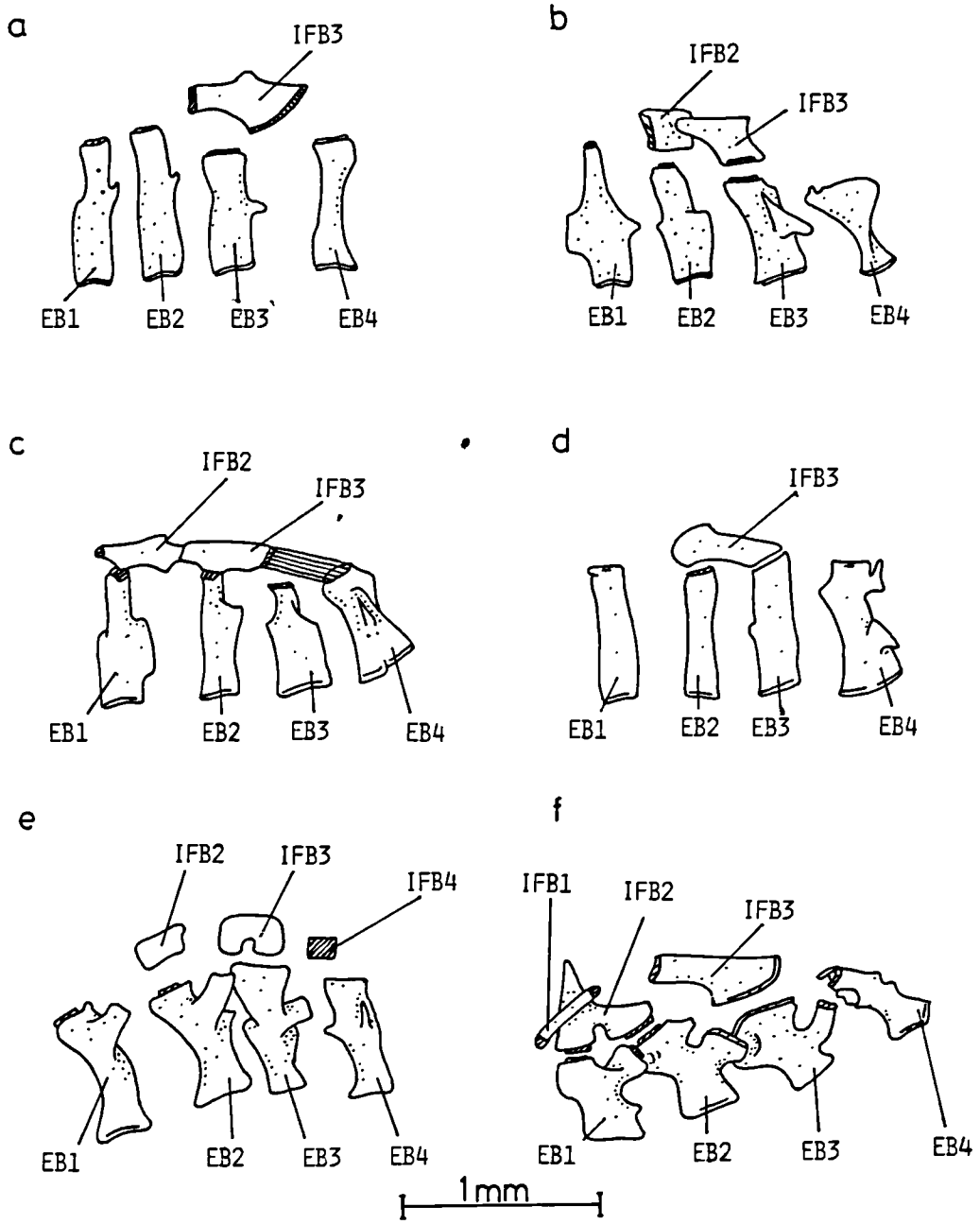

a
IFB3
EB1
EB2
EB3
EB4
b
IFB2
IFB3
EB1
EB2
EB3
EB4
c
IFB2
IFB3
EB1
EB2
EB3
EB4
d
IFB3
EB1
EB2
EB3
EB4
e
IFB2
IFB3
IFB4
EB1
EB2
EB3
EB4
f
IFB1
IFB2
IFB3
EB1
EB2
EB3
EB4
1mm

Fig. Lxxxviii Hypothesis of cobitoid relationships based on branchial ontogeny characters proposed by Nakajima [in press 1981]

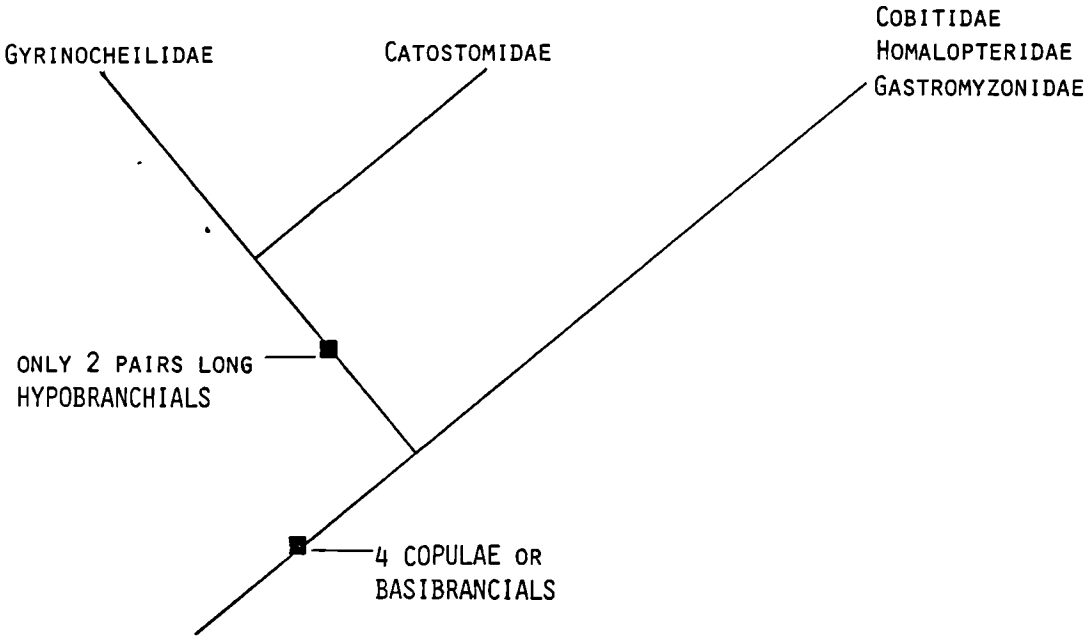

GYRINOCHEILIDAE
CATOSTOMIDAE
COBITIDAE
HOMALOPTERIDAE
GASTROMYZONIDAE
ONLY 2 PAIRS LONG
HYPOBRANCHIALS
4 COPULAE OR
BASIBRANCIALS

Fig. Lxxxix Left inferior pharyngeal bone (Dorsal view)

a. Noemacheilus montanus

b. Botia modesta

c. Lepidocephalus annandali

d. Vaillantella flavofasciata

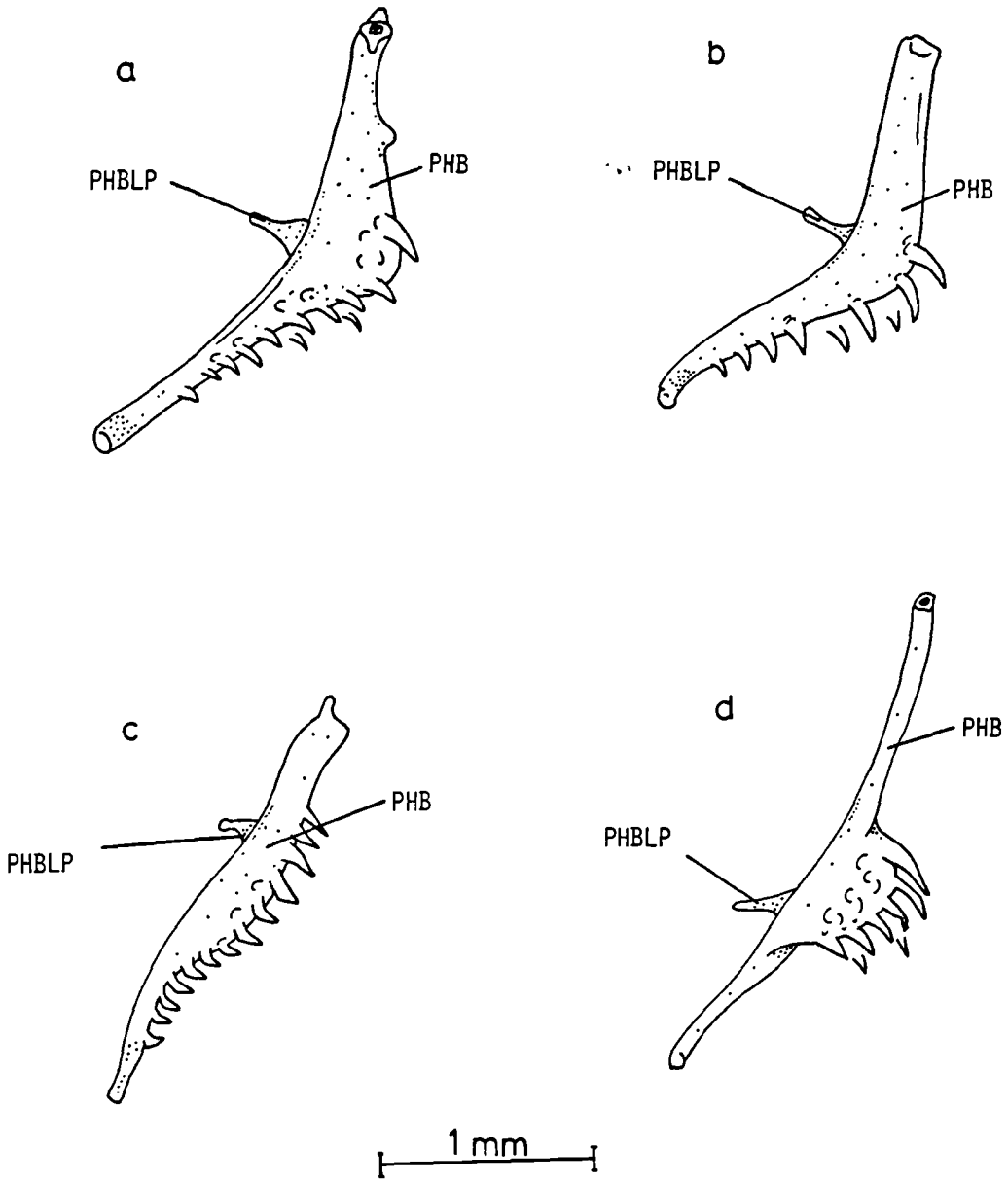

a
PHBLP
PHB
b
PHBLP
PHB
c
PHB
PHBLP
d
PHB
PHBLP
1 mm

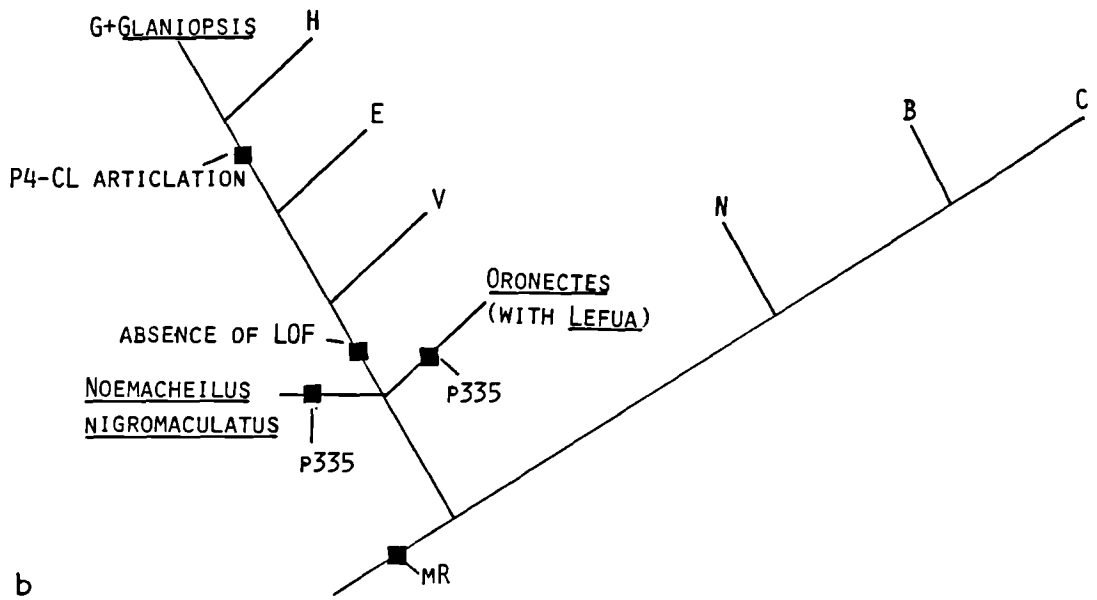
Fig. xC Photograph of electron microscope appearance of surface of barbel of Misgurnus anguillicaudatus

×500

×1,500

Fig. xCi Branching diagram showing hypotheses of noemacheilid phylogeny based on the characters discussed on p.332-6of this thesis.

a


G+GLANIOPSIS
H
E
P4-CL ARTICLATION
V
B
C
N
ORONECTES
(WITH LEFUA)
ABSENCE OF LOF
P335
NOEMACHEILUS
NIGROMACULATUS
P335
MR

b

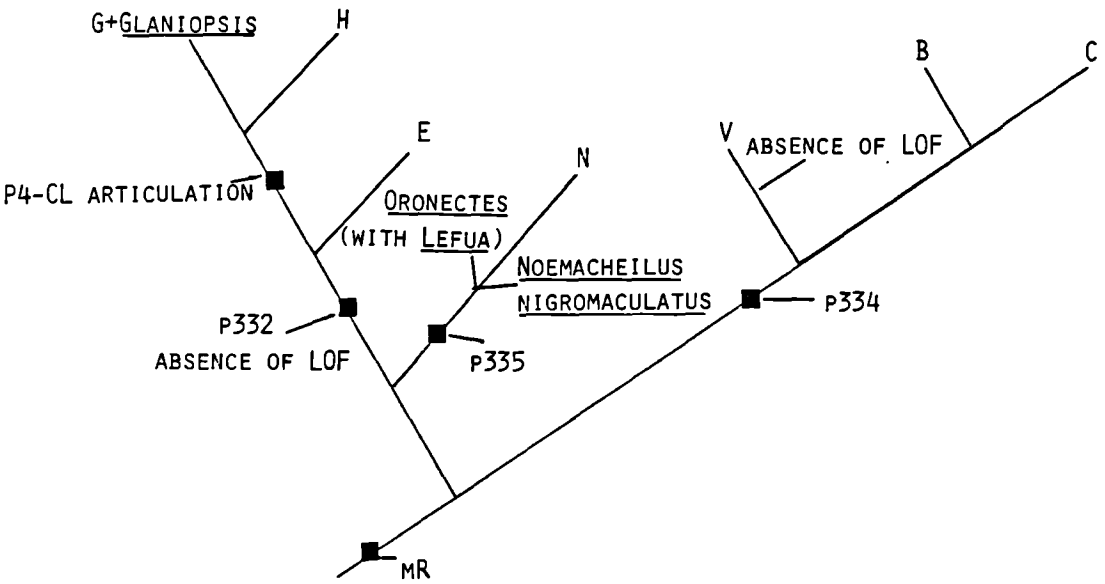

G+GLANIOPSIS
H
B
C
E
V
ABSENCE OF LOF
P4-CL ARTICULATION
N
ORONECTES
(WITH LEFUA)
NOEMACHEILUS
NIGROMACULATUS
P334
P332
ABSENCE OF LOF
P335
MR

Fig. xCii Branching diagram showing hypotheses of cobitine phylogeny based on the characters discussed on p.336-9 of this thesis.

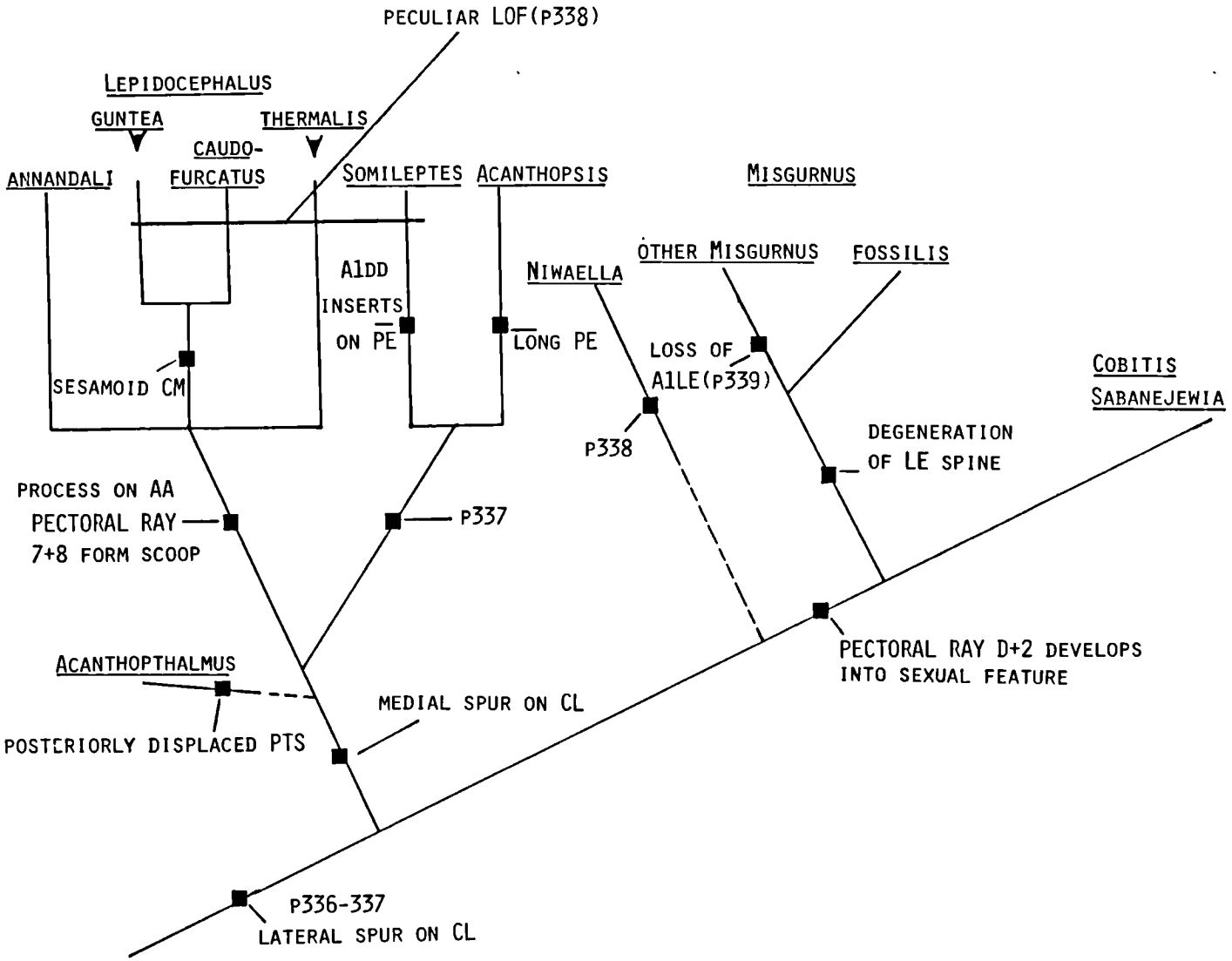

PECULIAR LOF(P338)
LEPIDOCEPHALUS
GUNTEA
THERMALIS
CAUDO-
FURCATUS
ANNANDALI
SOMILEPTES
ACANTHOPSIS
MISGURNUS
A1DD
INSERTS
ON PE
NIWAELLA
OTHER MISGURNUS
FOSSILIS
LONG PE
LOSS OF
A1LE(P339)
SESAMOID CM
COBITIS
SABANEJEWIA
P338
DEGENERATION
OF LE SPINE
PROCESS ON AA
PECTORAL RAY
7+8 FORM SCOOP
P337
ACANTHOPTHALMUS
PECTORAL RAY D+2 DEVELOPS
INTO SEXUAL FEATURE
MEDIAL SPUR ON CL
POSTERIORLY DISPLACED PTS
P336-337
LATERAL SPUR ON CL

Fig. xCiii Branching diagram showing hypotheses of botine phylogeny based on the characters discussed on p.340-2 of this thesis.

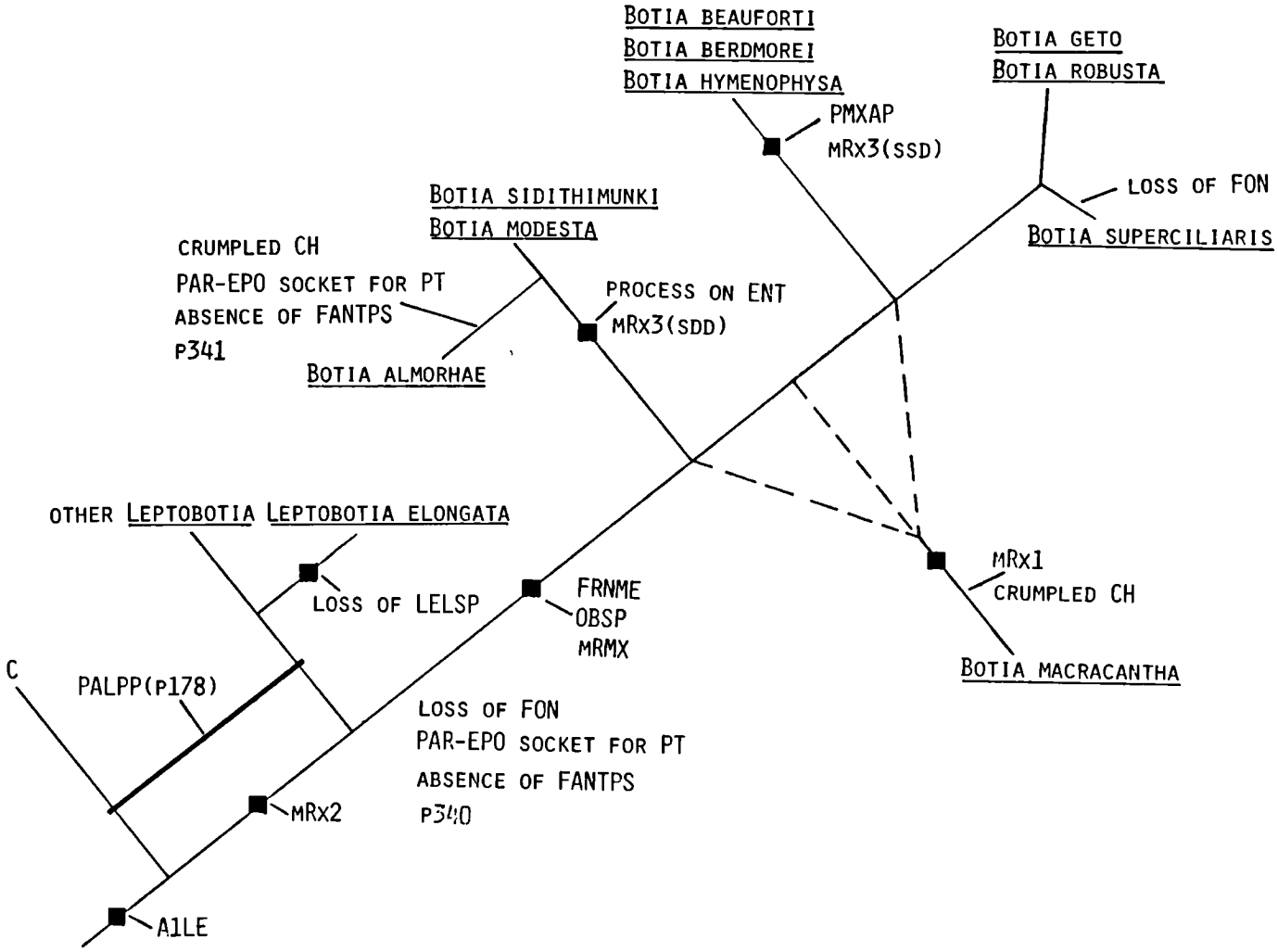

BOTIA BEAUFORTI
BOTIA BERDMOREI
BOTIA HYMENOPHYSA
PMXAP
MRx3(SSD)
BOTIA GETO
BOTIA ROBUSTA
LOSS OF FON
BOTIA SUPERCILIARIS
BOTIA SIDITHIMUNKI
BOTIA MODESTA
CRUMPLED CH
PAR-EPO SOCKET FOR PT
ABSENCE OF FANTPS
P341
PROCESS ON ENT
MRx3(SDD)
BOTIA ALMORHAE
OTHER LEPTOBOTIA LEPTOBOTIA ELONGATA
LOSS OF LELSP
FRNME
OBSP
MRMX
MRx1
CRUMPLED CH
BOTIA MACRACANTHA
C
PALPP(P178)
LOSS OF FON
PAR-EPO SOCKET FOR PT
ABSENCE OF FANTPS
P340
MRx2
A1LE

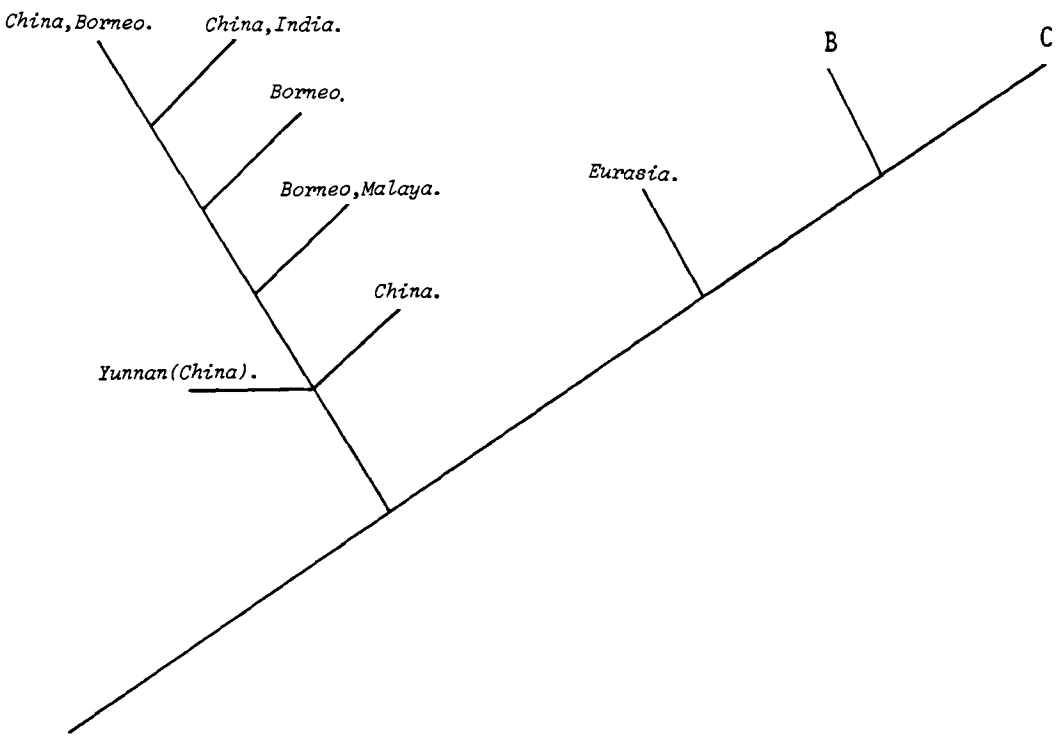
Fig. xCiv Superimposition of current-day geographical distributions on hypotheses of relationship of:-

a. noemacheilids

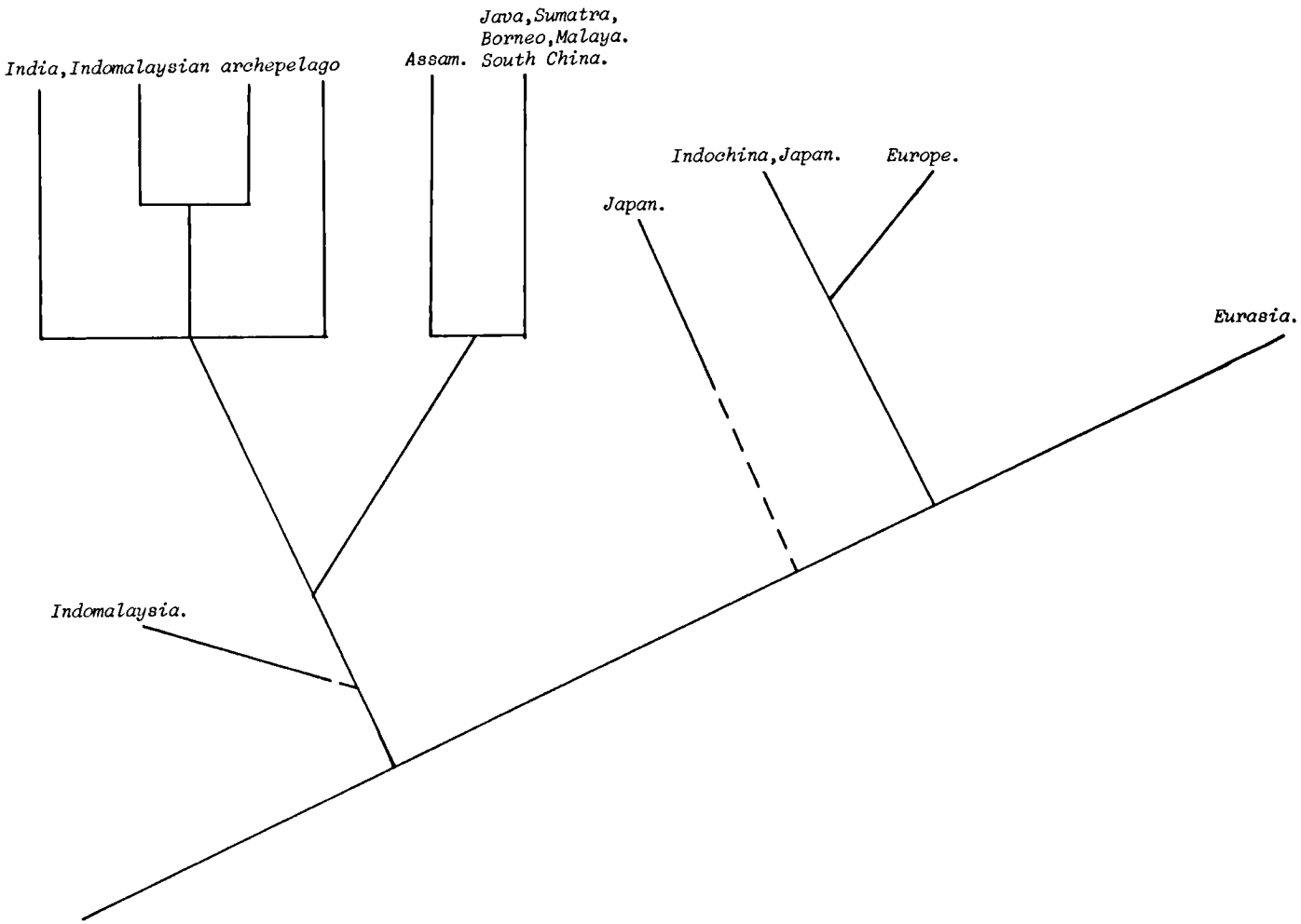
b. cobitines

c. botines.

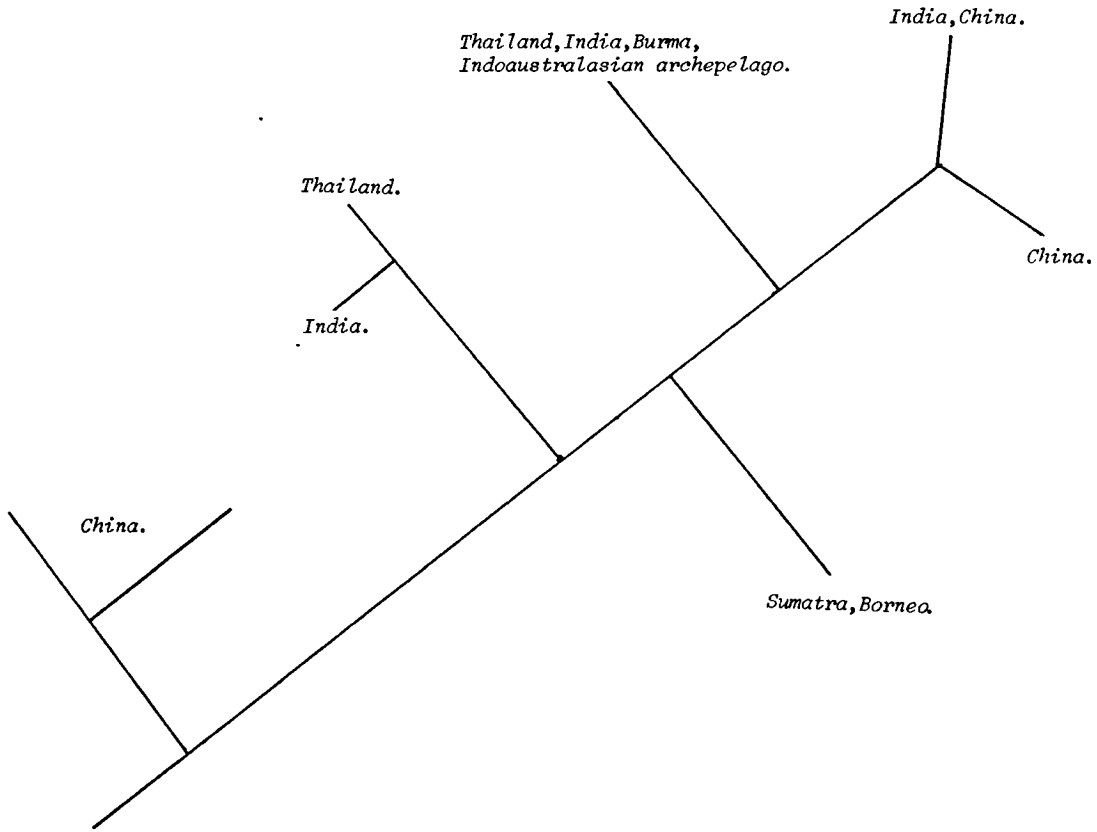
a


China,Borneo.
China,India.
Borneo.
Borneo,Malaya.
China.
Yunnan(China).
Eurasia.
B
C

b


India, Indomalaysian archepelago
Assam.
Java, Sumatra,
Borneo, Malaya.
South China.
Indochina, Japan.
Europe.
Japan.
Eurasia.
Indomalaysia.

C


India, China.
Thailand, India, Burma,
Indoaustralasian archepelago.
Thailand.
China.
India.
China.
Sumatra, Borneo.