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PLIO-PLEISTOCENE FOSSIL FISH REMAINS FROM KASHMIR VALLEY, NW INDIA: BIOCHRONOLOGY, SYSTEMATICS AND PALAEOECOLOGY

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ABSTRACT

Recently conducted underwater screening techniques on the Plio-Pleistocene Karewa sediments of the Kashmir intermontane basin, NW Himalaya, have resulted in large number of fossil fish remains belonging to at least four genera two of which are reported for the first time from the Plio-Pleistocene of India. Fifteen fossiliferous horizons yielding fossil fish remains are provided for the first time the absolute chronology in a biochronological sequence covering a time span of about 4 Myr. It is suggested that Schizothoracinae fishes were probably washed down from hill streams to get deposited in the low lying Karewa basin, hence are included in the upland community. On the other hand, Cyprininae fishes forming a part of the lacustrine community were present in the ancient Karewa lake during the sediment deposition.

INTRODUCTION

The Kashmir Valley in NW India is bounded by the Great Himalayan Range in northeast and the Pir Panjal Range in southwest, and has preserved a fairly long and continuous record of the Late Cenozoic sedimentation and the mountain building history of the last about 4.0 Myr in the form of continental deposits. These synorogenic sediments, about 1200 m in thickness, are commonly called as "Karewas" or "Karewa Group". The Karewas, large plateau — like terraces and comprising unconsolidated mudstone-sandstone-conglomerate succession, occupy nearly half of the area of Kashmir Valley, principally in the tract fringing northeastern slopes of the Pir Panjal Range and the left bank of River Jhelum and also in a few scattered areas on the right bank, SE of Srinagar (Fig. 1).

The reconnaissance of Karewa geology was initiated by Von Huegel (1840) and followed by Godwin-Austen (1864), Lydekker (1878), Middlemiss (1924), Sahni (1936), De Terra and Paterson (1939), Farooqi and Desai (1974), Bhatt (1975, 1979), Bhatt and Chatterji (1976) and Singh (1982). Subsequently, the detailed and high resolution studies with application of various geological and physical dating techniques were carried out; to understand the developmental history of the basin (Agrawal, Krishnamurthy, Kusumgar, Nautiyal, Athavale and Radhakrishnamurthy, 1979; Burbank and Johnson, 1982, 1983; Kusumgar, Agrawal and Kotlia, 1985; Kusumgar, Kotlia, Agrawal a. d Sahni, 1986) and finally to work out Late Cenozoic palaeoclimatic changes in the Valley (Agrawal, Krishnamurthy and Kusumgar, 1985; Agrawal, Dodia, Kotlia and Sahni, 1988). These multidisciplinary studies concluded that the Karewa deposition started about 4.0 Myr ago in a vast lake which was formed by the uplift of the Pir Panjal Range.

Vertebrate palaeontological research in the Karewas was started with the work of Godwin-Austen (1864), followed by Mukerji (1936), Hora (1937), De Terra and Paterson (1939), Badam (1968), Tewari and Kachroo (1977) and Sahni (1982). While working on the Karewas with application of various techniques, Kotlia, Sahni, Agrawal and Pant (1982) and Sahni and Kotlia (1983, 1985) carried out the systematic study of mega and microvertebrate fossils of the Karewas. With more new available data, Kotlia (1985a, b, c; 1986, 1987), described the detailed taxonomy of vertebrate fossils and prepared a biochronological sequence for well magnetic dated Karewa deposits.

The present report discusses the first biochronological sequence for the lower vertebrates (fossil fish remains) describing their systematic position and palaeoecological importance.

In accordance with the primary objective of the present study which is *in situ* collection of fossil fish remains and their biochronology, the author has investigated and measured four stratigraphic sections. These columns, largest of which is about 725 m (Hirpur section) provide framework for present palaeontological studies. Various sections are intercorrelated to provide a composite sequence which is well dated by physical dating techniques (Kusumgar *et al.*, 1985 1986).

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Measured sections are shown in Fig. 2. Sediments exposed at Dubjan, Hirpur and Krachipatra localities are exposed along River Rembiara near Hirpur village about 67 km SW of Srinagar. They are described together in Hirpur section which is a type section for the lower part of the Lower Karewas. Ichhagoz and Romu deposits, forming upper part of Lower Karewas are measured along River Romushi and described as Romushi section, type section for upper part of the Lower Karewas. Kilar section, about 60 km SW of Srinagar is exposed along Birnai Nala, a tributary of River Romushi, and is well correlated with the Romushi section on the basis of a conglomeratic bed. All sections are measured on Pir Panjal flank, forming the Lower Karewas. Sombur section, about 18 km SE of Srinagar is measured on Himalayan flank, forming a part of the Upper Karewas.

BIOCHRONOLOGY

Based on the geological observations, various workers assigned the base of the Karewas the different ages e.g., Miocene (Roy, 1975), Pliocene (Mid-

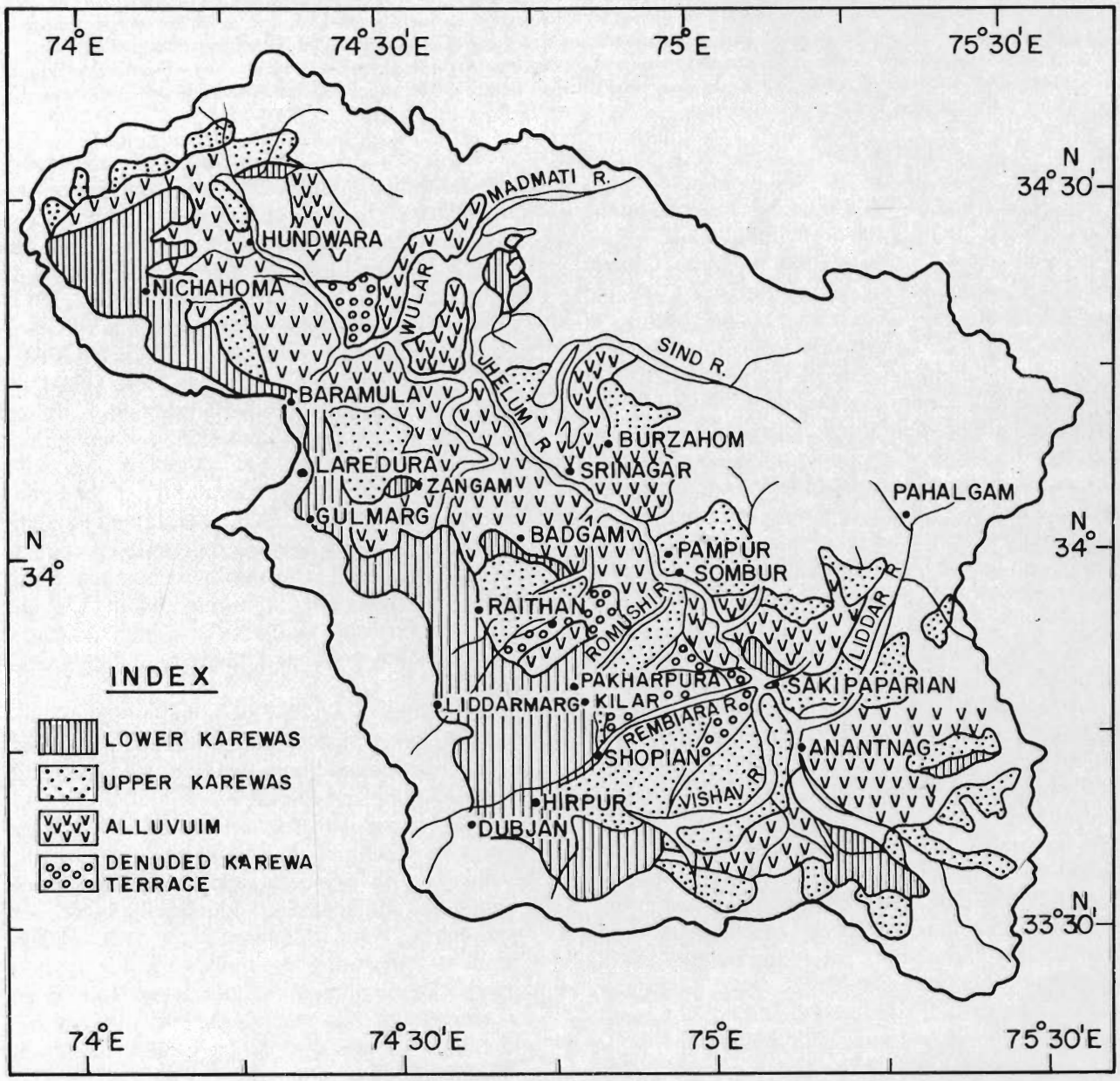

Figure 1. Geological map of the Kashmir Valley showing the distribution of Lower and Upper Karewas

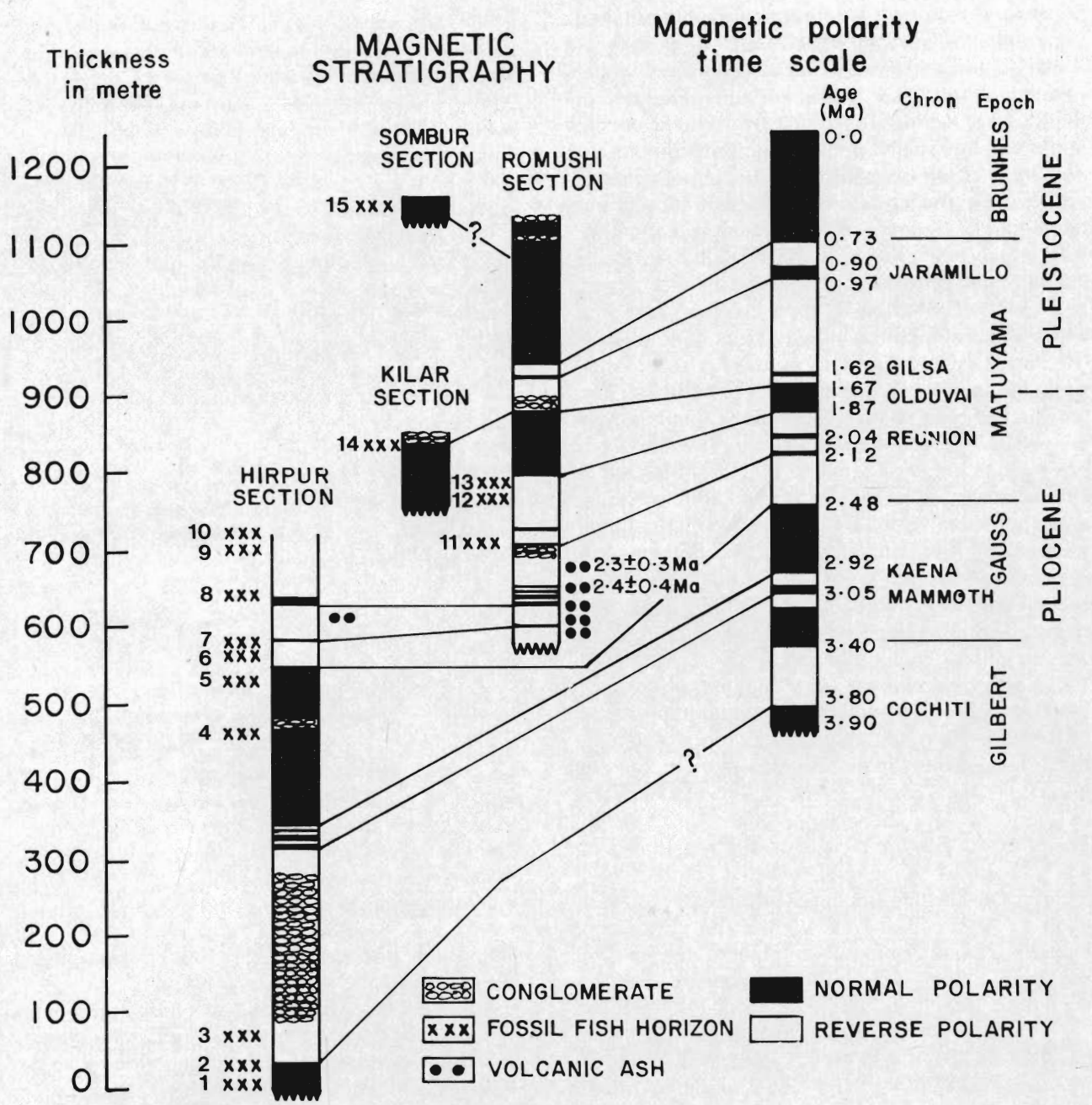

Figure 2. Fish biochronology of the Karewas (modified after Kusumgar *et al.*, 1986). The base of the Karewas extends to about 3.8 Myr. The Romushi and Kilara sections are correlated based on a conglomerate horizon, therefore the Romushi magnetic stratigraphy is used to date the Kilar sediments. Sombur fossiliferous horizon falls well within the Brunhes chron and is correlatable with the third Pleistocene worldwide dispersal event of the fossil arvicolids (Repenning, 1980; Kotlia, 1987), datable to 0.44 Myr.

dlemiss, 1924; Sahni, 1936; Wadia, 1951; Bhatt, 1975, 1979) and Pleistocene (Lydekker, 1878; De Terra and Paterson, 1939). Recently, the Karewa chronology was discussed through the combined use of magnetic polarity stratigraphy and fission track dating of volcanic ash by Burbank and Johnson (1982, 1983) and Kusumgar *et al.* (1985), and it became clear that the deposition of Karewas began with the upper Gilbert epoch (c. 4.0 Myr). Fission track dates of volcanic ash layers in the Romushi section were given by Burbank and Johnson (1982) and Kusumgar *et al.* (1985, 1986) to correlate Hirpur and Romushi sections. In

the present study, magnetic stratigraphy is taken from Kusumgar *et al.* (1986).

Fig. 2 shows measured Karewa sections and biochronology of fossil fish-yielding horizons. The base of the Karewas extends to the Gilbert magnetic epoch, about 3.8 Myr. The Hirpur and Romushi sections are correlated based on fission track dating of volcanic ash, found in the lower part of Romushi section and upper part of Hirpur section (Burbank and Johnson, 1982; Kusumgar *et al.* 1985, 1986). Kilar section is lateral extension of a part of Romushi section and both are correlated based on a conglomeratic bed which has been physically traced from Kilar to Aglar (Romushi). Table 1 describes various horizons, localities, chronology and faunas collected. The 1st, 2nd and 3rd horizons within an age limit of about 3.8 Myr are discovered from Dubjan locality. The 4th to 8th horizons with an age between 2.9 to 2.4 Myr are in Hirpur locality, whereas the 9th and 10th horizons, dated to about 2.4 Myr are represented by Krachipatra locality. The 11th, 12th, and 13th horizons are discovered from Ichhagoz locality in the Romushi section and are dated to 2.1 to 1.8 Myr. Kilar sediments, dated to top of the Olduvai event (1.6 Myr), are represented by 14th horizons. The rich fauna of 15th horizon is collected from Sombur village. This horizon is also represented by the third appearance of the arvicolid rodents in Kashmir, correlatable to the 3rd worldwide Pleistocene dispersal event of the arvicolid rodents (Kotlia, 1987). This event took place at about .44 Myr (Repenning, 1980; Kotlia, 1987). Therefore the Sombur sediments can be assigned an age of about .44 Myr in the Brunhes epoch.

Several distinctive lithologies were observed to be good for fossil vertebrates both in the Lower and Upper Karewas. The fossil fish remains, described in the present study were recovered mainly from four main depositional settings.

1. Organic and inorganic rich dark mudstone interbedded with thin lignite seams and consisting of mm scale laminations. The fossils associated with several gastropod shells have been collected from such depositional settings (1st, 2nd, 3rd and 13th horizons).

2. Fine grained greyish to bluish silty mudstone occasionally with finely laminated sandstone and claystone lenses which are fairly common in Hirpur and Romushi sections (4th, 5th, 6th, 7th, 8th and 12th horizons).

3. Dark greyish mustone interlayered with yellowish fine grained sandstone, full of gastropod shells and plant fossils, as exposed at Krachipatra (9th and 10th horizons).

4. Mollusc rich compact and bluish, sometimes greyish mudstone. The fine sandstone lenses embedded in mudstone have been proved to be richly fossiliferous (11th and 14 horizons).

5. Medium grained unconsolidated sandstone layers interstratified with laminated siltstone and light grey to yellowish patches of claystone as exposed at Sombur. The lithological setting also consists of small pebbles and gritty sandstone probably belonging to a conglomeratic bed (15th horizon).

Table 1

Horizon	Locality	Age (Myr)	Fauna
15th	SOMBUR	0.44	*Schizothorax esocinus* *Cyprinus carpio communis* *C. carpio scapularis, Oreinus, Schizopygopsis*
14th	KILAR	1.6	*C. carpio communis, S. esocinus*
13th	R	1.8	*S. esocinus*
12th	O		*Oreinus*
	M		*C. carpio communis*
	U		*S. esocinus*
11th	S	2.1	*S. esocinus*
	H		
	I		
10th	KRACHI-		*C. carpio communis,*
	PATRA		*Oreinus*
9th			*Oreinus*
			C.carpio communis
			S. esocinus
8th	H	2.4	*S. esocinus*
	I		
7th	R		*C. carpio communis*
	P		*S. esocinus*
6th	U	2.5	*C. carpio communis*
	R		*S. esocinus*
5th		2.5	*S. esocinus*
4th			*C. carpio communis*
			S. esocinus
3rd	D		*S. esocinus*
2nd	U	3.8	*S. esocinus*
1st	B	3.8	*S. esocinus*
	J		
	A		
	N		

PALAEONTOLOGY

The studies of lower vertebrates of Karewa sediments date to the time of Godwin-Austens (1864)

report of fish scales from Gogajipathri, Liddarmarg and Yushmarg. Consequently at that time no systematic record was kept as to the exact locality or even of the horizons from which the fish remains were obtained. De Terra, during his "Yale North India Expedition" in 1932 and 1935, collected a number of fossil fish remains in Kashmir which were later on described by Mukerji (1936) and Hora (1937). Mukerji (1936) found a series of forms, intermediate between *Schizothorax* and *Oreinus* and described the hybrid forms. Mukerji (1936) also pointed out that those forms even at present day are the dominant element in the fish fauna of Kashmir Valley. Hora (1937) referred entire material to the subfamily Schizothoracinae (Family: Cyprinidae) and indicated that the fossil fishes were closely allied to *Schizothorax* and *Oreinus*.

Recently, Sahni and Kotlia (1985) published the preliminary results of the present collection and described initially collected material under the family Cyprinidae and suggested that the fossils belonged to *Schizothorax-Oreinus*. The study of lower vertebrates of the Karewas, therefore, is confined mainly to the contribution of Hora (1937) and Sahni and Kotlia (1985) except for a small report of some unidentifiable and unfigured compressed fish vertebrae and few insects by Tripathi and Chandra (1971) from the Lower Karewas exposed at Nichahoma. Hora's (1937) contribution on the taxonomy and morphology of Karewa fishes was based on the collection made by De Terra as well as the specimens belonging to the collection of Chu (1935) from China, whereas Sahni and Kotlia (1985) in addition to the existing literature and material, compared the fossils with skeletons of present day fishes living in and around Kashmir Valley.

Additional data obtained from a collection comprising over 6000 fragmentary isolated skeletal elements made by author during 1984-1986 have helped in revising and up-dating the original identification and conclusions of Hora (1937) and Sahni and Kotlia (1985). The present collection includes numerous pharyngeal teeth, jaws, opercula, trunk vertebrae, dorsal spines and thousands of other skeletal remains. For comparisons of the Karewa fishes in the present faunal collection, the skeletons of a number of present day species of fishes found in rivers, ponds and lakes of Kashmir Valley were obtained. As will be elaborated further, the skeletal reconstruction of Karewa fishes correspond very closely to those of their Recent counterparts. Main criteria of differentiation are: size and arrangement of pharyngeal teeth; morphology of opercula; nature of spines; and morphology of pharyngeal arch, ramus and other bone fragments.

SYSTEMATIC PALAEONTOLOGY

Class Osteichthyes
Subclass Actinopterygii
Infraclass Teleostei
Superorder Ostariophysi
Order Cypriniformes
Suborder Cyprinoidei
Family Cyprinidae

1. Pharyngeal teeth.

Subfamily Cyprininae
Genus *Cyprinus*

Cyprinus carpio communis
(Plate I — 1-7; Plate — II 1-8)

Material: VPL/B 1400-1402; VPL/B 1451-1452; VPL/B 1800-1801; VPL/B 1409-1410; VPL/B 1455-1458; VPL/B 1805-1806. All isolated pharyngeal teeth.

Horizons: 1400-1402 and 1451-1452 were recovered from 9th and 10th horizons respectively. 1800-1801 were collected from 14th horizon. 1409-1410, 1455-1456, 1457-1458 and 1805-1806 were form 4th, 6th, 15th and 12th horizons respectively.

Description: Small to medium sized (2.5 mm-8.5 mm) teeth are cylindrical to semi-circular in outline. The grinding surface is fully exposed with the crown oval to semi-circular, occasionally triangle in outline. In some specimens, there are ridges and furrows on the crown, extending along the anteroposterior diameter of tooth. The peripheral margin of crown is smooth. The kind of teeth shown in Plate I are generally situated anteriorly towards the ceratobranchial in the dentary, whereas other teeth (Plate II) are found to be situated posteriorly. Both kinds of crown patterns are found in *Cyprinus carpio communis*.

Subfamily Schizothoracinae
Genus *Schizothorax*

Schizothorax esocinus
(Plate III — 1-10; Plate IV — 1-9)

Material: VPL/B 1403-1404; VPL/B 1502; VPL/B 1516-1517; VPL/B 1524; VPL/B 1552-1554; VPL/B 1533-1535; VPL/B 1682-1683; VPL/B 1804; VPL/B 1850; VPL/B 1631-1632. All isolated pharyngeal teeth.

Horizons: 1403-1405 were collected from 9th horizon. 1502, 1516-1517 and 1524 were from 4th, 6th and 7th horizons respectively. 1533-1535 were from 12th bone bed. Specimens, 1552 and 1553-1554 were collected from 1st and 3rd horizons respectively. 1682 and 1683 came from 11th and 13th horizons. 1804 form 14th, 1850 from 8th and 1631-1632 were from 15th horizon.

Description: The pharyngeal teeth range in size from 1 mm to 11 mm and are conical to cylindrical in outline. The grinding surface is well exposed and inclined obliquely thus producing a pointed to slightly smooth tip. The outline of the crown is elliptical to semi-circular. This type of teeth are characteristic of Schizothoracinae genera, such as *Oreinus* and *Schizothorax* (Chu, 1935). It can be suggested that present fossil teeth belong to *Schizothorax esocinus*, a present day fish found in the higher streams of the Valley.

2. Dorsal spines

Subfamily Schizothoracinae

The present faunal collection consists of more than 150 individual dorsal spines of which 80% are too fragmentary and broken. Fragments of dorsal spines with diagnostic characters formed the basis for categorising into two types. Specimens have been identified by comparison with Recent and fossil comparative material, known from the Kashmir Valley.

Schizothorax esocinus
(Plate — V 1-12)

Material: VPL/B 1445-1446; VPL/B 1494-1495; VPL/B 1600-1607; All incomplete spines. 1445-1446. 1495 and 1606 are right dorsal spines and 1494, 1600-1605 and 1607 are left spines.

Horizons: 1445-1446 were collected from 9th bone bed. 1494-1495 from 2nd, 1600-1605 from 15th and 1606-1607 were from 5th horizon.

Description: Dorsal spines are stout, long and slightly convex elements. In most of the specimens, specially VPL/B 1494-1495 and VPL/B 1606, the proximal end bears an articulating head marked by numerous fine ridges and furrows. The specimens are distinguished from other types on the basis of anterior serrae and nature of posterior denticles. Anterior serrae are very weakly developed, while posterior serrae are long, strong, unipointed and anteriorly directed, making an acute angle with the spine. The dorsal surface is ornamented by a single well developed longitudinal striation and a few very poorly developed accessory striations, arising from the proximal end. By careful comparisons, it is suggested that the fossil spines belong to *Schizothorax esocinus*.

Oreinus
(Plate VI — 1-11)

Material: VPL/B 1447; VPL/B 1611-1614; VPL/B 1449; VPL/B 1616-1619; VPL/B 1479. All broken spines. 1447, 1611-1614, and 1616 are left spines. 1449, and 1617-1619 are right spines. 1479 is unidentifiable.

Horizons: 1447 and 1479 came from 10th horizon. 1611-1614 and 1616-1619 were collected from 12th and 15th horizons respectively. 1449 was from 9th horizon.

Description: VPL/B 1447 is broken posteriorly. The priximal end is well developed showing an articulating head, marked by ridges and furrows. There is not well marked longitudinal striation on the spines. VPL/B 1611-1614 are broken anteriorly and posteriorly without any sign of proximal head. The denticles are weakly packed and are feeble (VPL/B 1614) and directed forwardly (VPL/B 1612). The denticles in VPL/B 1612 form almost a right angle to longer axis of the spine. Some spines (VPL/B 1449, 1616-1619) are marked by a well developed longitudinal striation and a few accessory striations. The denticles are long, conical and directed anteriorly. The space between two denticles is more than that of *Schizothorax esocinus*. The preserved portions of the spines are strongly denticuated on the inner border. The serrations are simple, long, unipointed, directed antieriorly and widely spaced.

The character of feebleness of spines is always found in Schizothoracinae (Hora, 1937; Sahni and Kotlia, 1985). The spines are strongly serrated in *Oreinus*. Because of the preservation and transportation factors, some spines may lose the strong serrations to become feeble. The present spines can be referred to the genus *Oreinus* based on two kinds of nature of serrations.

3. Pharyngeal arch.

(Plate VII — 1,2)

Material: VPL/B 1623, a broken right pharyngeal arch with a complete tooth; VPL/B 1624, a broken part of pharyngeal arch with a complete tooth.

Horizon: Both the specimens were collected from 15th horizon.

Description: Posteriorly broken right pharyngeal arch (VPL/B 1523) consists of a single medium-sized tooth which is slightly curved upwardly. The grinding surface of tooth is fully exposed, having a crown which is nearly circular in outline. There are three alveoli and one complete tooth in the major row and three alveoli in the inner row of the pharyngeal arch. The anterior limb (ceratobranchial) is well preserved and slightly curved on anterior side, the place at which present specimen is broken. The anterior part of ceratobranchial is wider than that of posterior part. The alar angle is wide. The posterior limb of pharyngeal arch is wider with an expansion of base of the posteriormost tooth in the major row. The arch has a well developed platform for posterior teeth.

VPL/B 1624 is a part of pharyngeal arch with a conical tooth which is slightly hook shaped with a grinding surface beneath hook. The pharyngeal arches of a number of species of presently occurring fishes were examined and it was found that the fossil arch, VPL/B 1623 is of *Cyprinus carpio communis*, whereas VPL/B 1624 belongs to *Schizothorax esocinus*.

4. Ramus

(Plate VII — 3)

Material: VPL/B 1665, an incomplete left ramus of lower jaw.

Horizon: The specimen was collected from 15th horizon.

Description: Well preserved ramus consists of a paired dentary and is broken anteriorly near symphysis meckelli. The ascending angular processes are almost of the same height. Dentary is long, curved and united in a median plane by posterior part of symphysis meckelli, possessing a posteriorly forked border interdigitating with corresponding articular facet. The anterior teeth of the dentary are in a patch consisting of an outermost row of small alveoli and a number of smaller uniform sized sockets internally. The articular facet is narrow and small, having an anterior expanded margin which interdigitates with dentary and posteroventrally elongated shallow facet for the reception of quadrate head.

A sensory canal enters into the dentary by an aperture lying on posteroventral margin of dentrary. The retro-articular is roughly triangular in outline, having a broad notch just beneath the articular facet. Based on the morphology, present specimen is referred to *Schizopygopsis* (Subfamily: Schiszothoracinae), a living stream fish of Kashmir.

5. Isolated vertebrae

(Plate VII — 4)

Material: VPL/B 1499, isolated vertebra; Many other unfigured specimens.

Horizon: The specimens came from 4th horizon.

Description: Although total number of vertebrae exceed more than a thousand in the collection, these elements are of little diagnostic value and cannot be referred with any certainty to any known genera and species except for a part of the vertebral column (VPL/B 1499) which is broken anteriorly and posteriorly, so without anal and caudal fins. The column is long consisting of at least ten branched rays with four well preserved vertebrae. This region of fossil fish resembles the corresponding region of *Cyprinus*, though the whole structure is of such a generalised nature that by itself it is not suitable for specific determination.

6. Non serrated rays

(Plate VII — 5-8)

Material: VPL/B 1496, broken non serrated ray; VPL/B 1678-1679, incomplete rays.

Horizons: All specimens came from 15th horizon.

Description: The articular head is well developed with a median ridge which extends towards distal end of the ray. A prominent notch is present on the articulating head, probably for attachment to the muscles. The rays become narrower towards distal portion. Based on the study of broken and a few numbers of non serrated rays, it is difficult to compare the present specimens with Recent fishes upto the specific level. However, specimens show a close similarity with non serrated rays of *Carpinus carpio communis*.

7. Opercular apparatus.

The paired bones, operculum, preoperculum, suboperculum and interoperculum constitute the opercular apparatus and among them only the opercula are present in this faunal collection. Operculum is the largest bone of the opercular apparatus, bearing anterodorsally a facet for articulation of the corresponding head of hyomandibular. Studies based on the size, shape, nature and morphology, suggest that there are at least three kinds of opercula in this material.

TYPE 1
(Plate VII — 9-12; Plate VIII — 1-4)

Material: VPL/B 1666-1667, incomplete opercula of right side; VPL/B 1668, incomplete operculum of left side.

Horizon: All specimens were collected from 15th horizon.

Description: The dorsal surface is smooth and flat. The articular facet that attaches to hyomandibular is well developed. Ventral surface is slightly convex having few ridges and furrrows. Upper margin which joins preoperculum is nearly straight. The faunal material may be referable to *Schizothorax esocinus*.

TYPE 2
(Plate VIII — 5-8)

Material: VPL/B 1670-1671, broken opercula of right side; VPL/B 1672, incomplete operculum of left side.

Horizon: 1670-1671 and 1672 were recovered from 15th and 7th horizons respectively.

Description: Dorsal surface is slightly convex. The articular facet is better developed having strong ridges and furrows on ventral side. The articular ridge forms an obtuse angle with upper margin of operculum which joins to preoperculum. The anterior margin which arises from articular ridge forms almost a straight line downwardly. VPL/B 1672 has a prominent articular facet with numerous ridges and furrows. The anterior margin of opeculum is slightly curved posteriorly. The dorsal surface is slightly concave and perforated on upper margin near articular facet. Present specimens are charactgerised by the upper margin of operculum forming almost a right angle to anterior margin and the operculum possesses a poorly developed articular facet. It can be suggested that the fossil opercula show very close similarty with those of *Cyprinus carpio communis*.

TYPE 3
(Plate VIII — 9-12)

Material: VPL/B 1673, nearly complete opeculum of right side; VPL/B 1674-1675, broken opercula of left side.

Horizon: 15th horizon.

Description: VPL/B 1673 is nearly a complete operculum, consisting of strongly developed articular facet which has a slender and broad expansion. The dorsal surface of operculum is smooth and concave. The anterior margin is smooth, concave and directed posteriorly forming nearly a right angle to upper margin. Ventral side consists of strongly developed ridges and furrows. VPL/B 1674 has a well developed articular facet with few ridges and furrows on ventral side of the operculum. Upper margin forms nearly a right angle to anterior margin but the articular facet has not strongly developed expansion. VPL/B 1675 is broken operculum having well developed articular facet with strongly developed expansion which is generally attached to hyomandibular. The present specimens are more closely allied to *Cyprinus carpio scapularis* than to any other fishes of entire Kashmir Valley.

COMMUNITY STRUCTURE OF KAREWA FISHES

Reconstruction of palaeocommunity serves to integrate the faunal record into a useful tool to infer palaeoenvironment, climatic changes, palaleogeography and extinction of past biota. From the present evidence, two communities can be distinguished in the Karewa fish material.

UPLAND COMMUNITY

This community is represented by Schizothoracinae fishes, specimens of which, at present, are recovered from altitudes as high as 3600 m (Mukerji, 1936; Sahni and Kotlia, 1985). This indicates that the mountains, surrounded the Karewa basin were at least of this altitude during the time of Karewa deposition, while the basin itself was at about 1500 m m.s. 1. The skeletal elements are not repesented in proportions that would be expected if complete animals were preserved. Further, the bones also show signs of transportation in the forms of abraded corners and edges, and preburial surface damage. It appears that the specimens were washed down from higher areas by streams into the low lying lake basin and consequently hard, durable and dense bone material was preferably preserved.

LACUSTRINE COMMUNITY

This community is reprsented by Cyprininae fishes, living counterparts of which are found today in the Kashmir Valley at the lower altitudes, about 1700 m (Mukerji, 1936; Sahni and Kotlia, 1985). Specimens of this group were probably had forested cover inhabited by the mammals and was interesected by streams having cyprinid fishes, together with fresh water ostracodes and gastropods which are common invertebrate fossils in the Karewas.

DISCUSSION

In the Indian subcontinent, the Plio-Pleistoncene occurrences of the family Cyprinidae are confined to the Karewas and Chitral (Hora, 1936, 1937; Sahni and Kotlia, 1985). From the structure of jaws, pharyngeal teeth, opercular apparatus, various spines, non serrated rays and vertebrae, the present material is referred to subfamilies Schizothoracinae and Cyprininae and to the genera, *Schizothorax*, *Oreinus*, *Cyprinus* and *Schizopygopsis*. It has been indicated (Hora, 1937) that *Schizothorax* and *Oreinus* are very closely related and capable of interbreeding. Hora (1937) also pointed that *Oreinus* represented fluviatile form of *Schizothorax*. However, *Schizothorax*, *Oreinus Cyprinus*, at present, are well represented and indentified in the lakes and larger streams of the Kashmir Valley. The author therefore opines that it may not be difficult to differentiate in the Plio-Pleistocene samples, the different dental and skeletal elements of *Schizothorax* and *Oreinus*. It may also be mentioned that the fossil fishes approximate in the frequency of occurrence to that found today in the lakes, streams and rivers of Kashmir. At present, the family Cyprinidae is represented by several genera, found in Kashmir. Important are *Schizothorax*, *Oreinus*, *Schizopygopsis*, *Cyprinus*, *Gliptothorax*, *Ptychobarbus* and *Diptychus*. The dominant species are *Schizothorax esocinus*, *S. planifrons*, *S. curvifrons*, *Cyprinus carpio communis*, *C. carpio scapularis*, *Schizopygopsis stoliczkae* and *Oreinus sinuatus*.

Fossil fishes belonging to the family Cyprinidae are still unknown in the nearby Siwalik sediments. The distributional disparity is probably a result of palaeoecological differences because even after allowing the Pleistocene uplifts in the Kashmir basin, these sediments appear to have been deposited at a higher elevation than that of the Pinjor Formation. This hypothesis gets further support from the distribution of fossil arvicolid rodents in the Kashmir Valley (Kotlia, 1985c, 1986, 1987), living counter-parts of which are presently known to occur at high altitudes of above 3000 m (Prater, 1971; Kotlia, 1985c). These voles probably inhabited the banks of upland streams which washed down their remains along with Schizothoracinae fishes into the accumulating sediments of the Karewa lake. Follwing the view of Sahni and Kotlia (1985), the author suggests that the faunal material was transported from both long and short distances and was probably secondarily concentrated in the basin. Schizothoracinae fishes were washed down from the upstreams and deposited in low lying Karewa basin, whereas Cyprininae fishes might have occupied the lower altitudes.

The study suggests that the Karewas were deposited in a lacustrine basin. The Lower Karewa sedimentation started in a lake, formed as a result of ponding of the southwardly flowing drainage by the initial upliftment in the Pir Panjal Range. A number of streams left the surrounding mountain ranges to offload their sediment load, which often included microvertebrate remains. The lacustrine sedimentation was interrupted for a few times by sharp uplift in the Pir Panjals resulting in the deposition of thick conglomerate beds. Subsequently, the lower Karewa lake shrank from southwestern to northeastern part of the Kashmir Valley in which deposited the Upper Karewas (Bhatt, 1979; Singh, 1982; Kotlia, 1985a). The conglomerates were probably deposited during cold climatic conditions, whereas the sandstones, mudstones and claystones might suggest abundant intermittent rainfall.

The study makes an attempt, for the first time, to work out the cyprinid biochronology which seems to be very well documented from the basement of the Karewas (c. 3.8 Myr) till the middle part of the Romushi section (c. 1.6 Myr). The latest data based on the pollen and Oxygen isotope studies of a part of the Karewa sequence (Agarwal *et al.*, 1988) suggest that the climate during the deposition of Dubjan sediments (marking 1st, 2nd, 3rd fossiliferous horizons of present work) and of a part of Hirpur sediments (particularly 6th, 7th and 8th horizons in this study) fluctuated between cool temperate to warm temperate with a little variation in precipitation. Similar kind of climate, according to Agarwal *et al.* (1988), persisted during the deposition of Krachipatra sediments (yielding fish remains of 9th and 10th horizons) as well as of the lower part of Romushi sediments. The biochronology of fossil fish remains in the upper part of the Romushi sediments is very poor, and the climate during their deposition changed to cold/glacial type as has been suggested by Agrawal *et al.* (1988). While comparing the broad climatic sequence and the occurrence of fossil fish remains, it can be suggested that the fishes were dominant in the Kashmir Valley whenever the basin experienced the cool temperate/warm temperate type of climate, as of today.

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REFERENCES

AGRAWAL, D.P., DODIA, R., KOTLIA, B.S. & SAHNI, A. 1980. The Pleistocene geologic and climatic record of the Kashmir Valley, India: A review and new data. *Palaeogeogr. Palaeoclimatol. Palaeoecol.* (communicated).

AGRAWAL, D.P., KRISHNAMURTHY, R.V. & KUSUMGAR, S. 1985. *Climate and geology of Kashmir and Central Asia: The Last Four Million Years.* Today & Tomorrows Printers & Publishers, New Delhi: 1-232.

AGRAWAL, D.P., KRISHNAMURTHY, R.V., KUSUMGAR, S., NAUTIYAL, V., ATHAVALE, R.N. & RADHAKRISHNAMURTHY, C. 1979. Chronostratigraphy of loessic and lacustrine sediments in the Kashmir Valley, India. *Acta. Geol. Acad. Scient. Hungari. Tomus.* **22**(1-4): 185-196.

BADAM, G.L. 1968. Notes on the occurrence of fossil vertebrates in the Karewas of Kashmir. *Rec. Bull. Panjab Univ.* **19**(3-4): 453-455.

BHATT, D.K. 1975. On the Quaternary geology of Kashmir with special reference to stratigraphy and sedimentation. *Misc. Publ. Geol. Surv. India.* **24**(1): 188-203.

BHATT, D.K. 1979. Lithostratigraphic sub-divisions of Hirpur Formation (Lower Karewas): A critical review and modification. *Him. Geol.* **9**: 43-52.

BHATT, D.K. & CHATTERJI, A.K. 1976. An appraisal of field observations on the Plio-Pleistocene Karewa Group and more recent Quaternary deposits of Kashmir Valley. *Proc. Sixth. Int. Coll. micropal. Strat. Varanasi*: 11-21.

BURBANK, D.W. & JOHNSON, G.D. 1982. Intermontane basin development in the past 4 Myr. in the northwest Himalaya. *Nature.* **298**: 432-436.

BURBANK, D.W. & JOHNSON, G.D. 1983. The Late Cenozoic and stratigraphic development of Kashmir intermontane basin, northwestern Himalaya. *Palaeogeogr. Palaeoclimatol. Palaeoecol.* **43**: 205-235.

CHU, Y.T. 1935. Comparative studies on the scales and on the pharyngeals and their teeth in Chinese cyprinids with particular reference to taxonomy and evolution. *Bull. Biol. Steh. Johns. Univ. Shanghai.* **2**: 62-67.

DE TERRA, H. & PATERSON, T.T. 1939. *Studies On The Ice Age In India And Associated Human Cultures.* Carnegie Institution, Washington. **93**: 1-354.

FAROOQI, Z.A. & DESAI, R.N. 1974. Stratigraphy of Karewas, Kashmir, India. *Jour. Geol. Soc. India.* **15**(3): 299-305.

GODWIN-AUSTEN, H.H. 1864. Geological notes on part of the northwestern Himalayas with notes on the fossils by T. Davidson, R. Etheridge and S.P. Woodward. *Quart. Jour. Geol. Soc. London.* **20**(4): 383-388.

HORA, S.L. 1936. The fishes of Chitral. *Rec. Ind. Museum.* **35**: 307-310.

HORA, S.L. 1937. On fossil fish remains from the Karewas of Kashmir. *Rec. Geol. Surv. India.* **72**(2): 178-187.

KOTLIA, B.S. 1985a. Vertebratae palaeontology and palaeoecology of the Karewa Group, Kashmir: A biostratigaraphic study. *Unpublished Ph.D. Thesis, Panjab Univ. Chandigarh*: 1-310.

KOTLIA, B.S. 1985b. Vertebrate fossils and palaeoenvironmnt of the Karewa intermontane basin, Kashmir, northwestern India. *Curr. Sci.* **54**(24): 1275-1277.

KOTLIA, B.S. 1985c. Quaternary rodent fauna of the Kashmir Valley: Systemataics, biochronology and palaeoecology. *Jour. Palaeont. Soc. India.* **30**: 81-91.

KOTLIA, B.S. 1986. First record of arvicolid rodent, *Pliopotamys*, from Kashmir Valley of Indian subcontinent. *Geosci. Jour.* **7**(2): 125-130.

KOTLIA, B.S. 1987. Discovery of fossil aravicolids in Indian subcontinent from Kashmir basin: Systematics and biochronology. *Publ. Geol. Surv. Czechoslovakia.* (in Press).

KOTLIA, B.S., SAHNI, A., AGRAWAL, D.P. & PANT, R.K. 1982. New vertebrate evidence for the age of the Karewa sediments, Kashmir. *Man. Environ.* **6**: 13-15.

KUSUMGAR, S., AGRAWAL, D.P. & KOTLIA, B.S. 1985. Magnetic stratigraphy of the Karewas of Kashmir Valley. In *Climate and Geology of Kashmir and Central Asia: The Last Four Million Years* (Ed. Agrawal. D.P. et al.) Today & Tomorrows Printers & Publishers, New Delhi: 13-18.

KUSUMGAR, S., KOTLIA, B.S. AGRAWAL, D.P. & SAHNI, A. 1986. Biochronologie des fossiles de verterbres des formations des Karewas du Cachemire, Inde. *L"Anthropologie.* **90**(2): 151-164.

LYDEKKER, R. 1878. Notes on the Geology of Kashmir, Kishtwar and Pangi. *Rec. Geol. Surv. India.* **10.1**(3): 88-171.

MIDDLEMISS, C.S. 1924. Lignite coal beds in the Karewa Formation of Kashmir Valley. *Rec. Geol. Surv. India.* **55**(3): 241-250.

MUKERJI, D.D. 1936. Yale North India Expedition. Part XVIII. Reports on fishes, Part II: Sisoridae and Cyprinidae. *Mem. Conn. Acad.* **10**: 323-359.

PRATER, S.H. 1971. The book of Indian animals. *Bom. Nat. Hist. Soc. Bombay*: 1-324.

REPENNING, C.A. 1980. Faunal exchange between Siberia and North America. *Canad. Jour. Anthropol.* **1**: 37-44.

ROY, D.K. 1975. Stratigraphy and palaeontology of the Karewa Group of Kashmir. *Misc. Publ. Geol. Surv. India.* **24**: 204-221.

SAHNI, A. 1982. Karewa verterbrates: biostrataigraphy, palaeohistology and palaeoecology. *Man. Environ.* **6**: 16-20.

SAHNI, A. & KOTLIA, B.S. 1983. Micromammals from the Karewa Group of Kashmir. *Man. Environ.* **7**: 157-158.

SAHNI, A. KOTLIA, B.S. 1985. Karewa microvertebrates: biostratigraphical and palaeoecological implications. In *Climate and Geology of Kashmir and Central Asia: The Last Four Million Years* (Ed. Agrawal, D.P. et al.) Today & Tomorrows Printers Publishers, New Delhi: 29-44.

SAHNI, B. 1936. The Karewas of Kashmir. *Curr. Sci.* **5**(1): 10-16.

SINGH, I.B. 1982. Sedimentation pattern in the Karewa basin, Kashmir Valley, India and its geological significance. *Jour. Palaeont. Soc. India.* **27**: 71-110.

TEWARI, B.S. & KACHROO, R.K. 1977. On the occurrence of *Equus sivalensis* from Karewas of Shupiyan, Kashmir Valley. *Recent. Res. Geol.* **3**: 468-477.

TRIPATHI, C. & CHANDRA, P.R. 1971. Fossils from the Karewas near Nichahoma, Kashmir. *Misc. Publ. Geol. Surv.* **15**: 261-267.

VON HUEGEL. C.F. 1840. *Kaschmir Und Des Reich Der Siex, Stuttgart*. Kayser (1840-1844).

WADIA, D.N. 1951. Plio-Pleistocene boundary in NW India. *Thirteenth. Int. Geol. Cong. London.* **18**: 43-48.

EXPLANATION OF PLATES

(Bar represents 1 mm. The occlusal/lateral/dorsal/ ventral views of individual specimen have same magnification)

PLATE I

Cyprinuns carpio communis (a, occlusal; b and c; lateral views)

1. VPL/B 1400
2. VPL/B 1401
3. VPL/B 1402
4. VPL/B 1451
5. VPL/B 1452
6. VPL/B 1800
7. VPL/B 1801 (all isolated teeth)

PLATE II

Cyprinus carpio communis (all isolated teeth)

1. VPL/B 1409 (a and b; lateral views)
2. VPL/B 1410 (a and b; lateral views)
3. VPL/B 1455 (a occlusal, and b and c; lateral views)
4. VPL/B 1456 (a and b; lateral views)
5. VPL/B 1457 (a; occlusal, and b and c; lateral views)
6. VPL/B 1458 (a and b; lateral views)
7. VPL/B 1805 (a and b; lateral views)
8. VPL/B 1806 (a; occlusal, and b and c; lateral views)

PLATE III

Schizothorax esocinus (a and b; lateral views)

1. VPL/B 1552
2. VPL/B 1553
3. VPL/B 1554
4. VPL/B 1502
5. VPL/B 1517 (c; occlusal view)
6. VPL/B 1516
7. VPL/B 1524
8. VPL/B 1403
9. VPL/B 1404
10. VPL/B 1405 (all isolated teeth)

PLATE IV

Schizothorax esocinus (a and b; lateral views)

1. VPL/B 1682
2. VPL/B 1683
3. VPL/B 1804
4. VPL/B 1533
5. VPL/B 1534
6. VPL/B 1535
7. VPL/B 1850
8. VPL/B 1631
9. VPL/B 1632 (all isolated teeth)

PLATE V

Schizothorax esocinus (a; dorsal, and b; ventral views)

1. VPL/B 1445
2. VPL/B 1446
3. VPL/B 1604
4. VPL/B 1600
5. VPL/B 1603
6. VPL/B 1601
7. VPL/B 1602
8. VPL/B 1605
9. VPL/B 1606
10. VPL/B 1607
11. VPL/B 1495
12. VPL/B 1494 (all spines)

PLATE VI

Oreinus (a; dorsal, and b; ventral views)

1. VPL/B 1447
2. VPL/B 1611
3. VPL/B 1612
4. VPL/B 1613
5. VPL/B 1614
6. VPL/B 1449
7. VPL/B 1616
8. VPL/B 1617
9. VPL/B 1618
10. VPL/B 1619
11. VPL/B 1479 (all spines)

PLATE VII

1. VPL/B 1623, *Cyprinus carpio communis* (a; dorsal, and b; ventral views), pharyngeal arach
2. VPL/B 1624, *Schizothorax esocinus* (a; dorsal, and b; ventral views), pharyngeal arch
3. VPL/B 1665, *Schizopygopsis* (a; dorsal, and b; ventral views views), lower left ramus
4. VPL/B 1499, *Cyprinus* (dorsal view), isolated vertebra

Cyprinus carpio communis (a; dorsal, and b; ventral views)

5. Recent
6. VPL/B 1678
7. VPL/B 1679
8. VPL/B 1496 (all non serrated rays)

Schizothorax esocinus (all dorsal views)

9. Recent
10. VPL/B 1666
11. VPL/B 1667
12. VPL/B 1668 (all opercula Type 1)

PLATE VIII

Schizothorax esocinus (all ventral views)

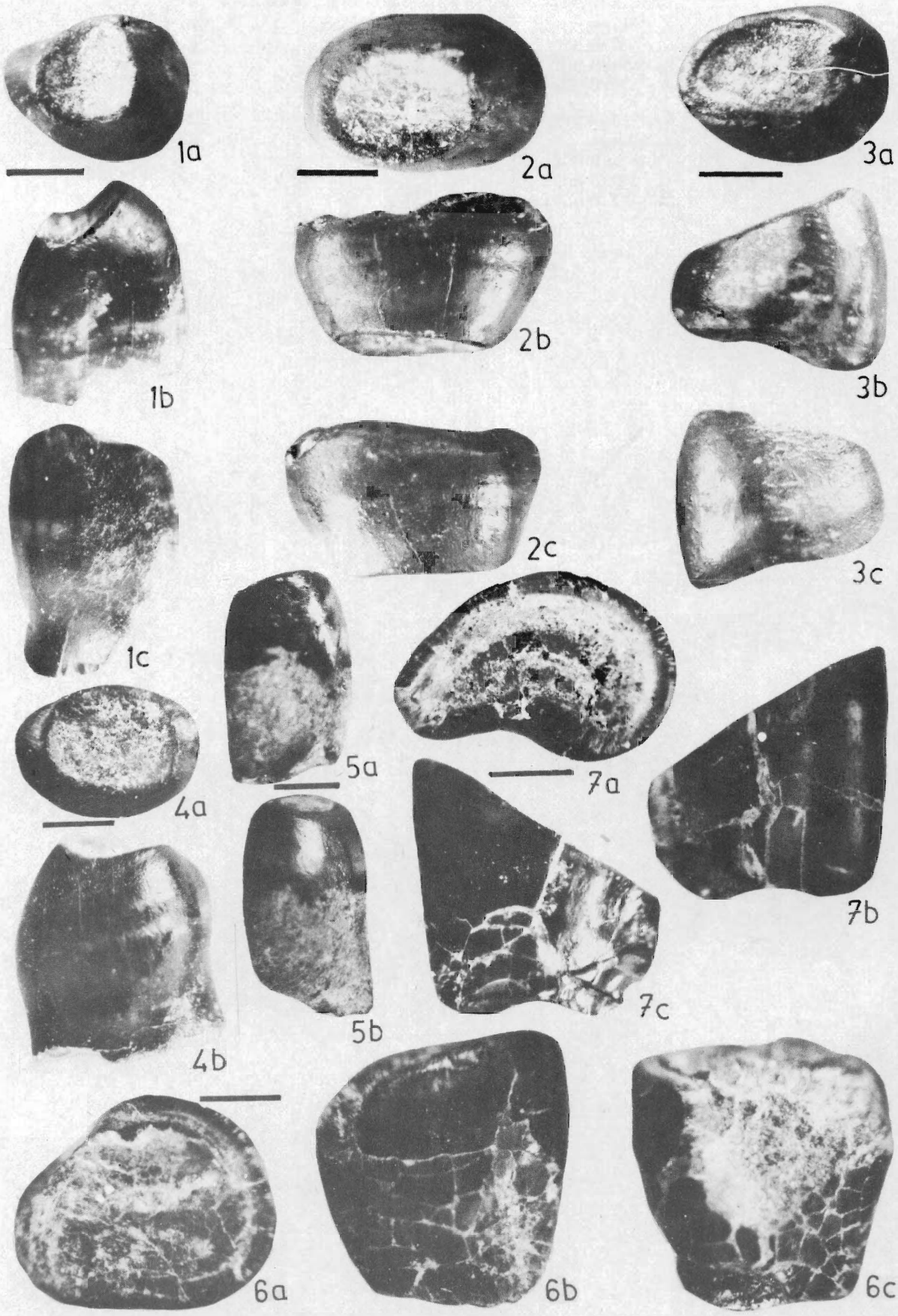
1. Recent
2. VPL/B 1666
3. VPL/B 1667
4. VPL/B 1668 (all opercula Type 1)

Cyprinus carpio communis (a; dorsal, and b; ventral views)

5. Recent
6. VPL/B 1670
7. VPL/B 1671
8. VPL/B 1672 (all opercula Type 2)

Cyprinus carpio scapularis (a; dorsal, and b; ventral views)

9. Recent
10. VPL/B 1673
11. VPL/B 1674
12. VPL/B 1675 (all opercula Type 3)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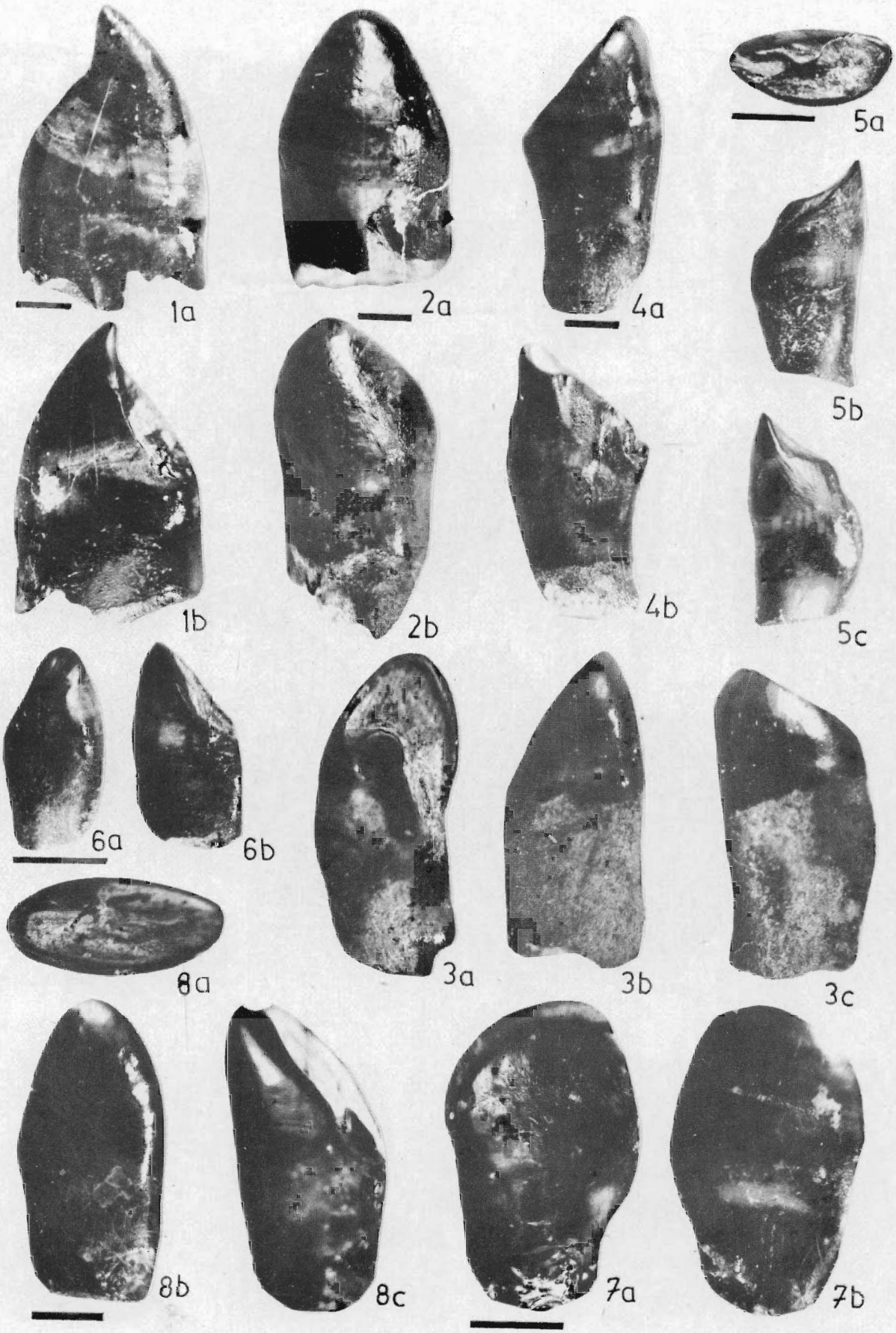
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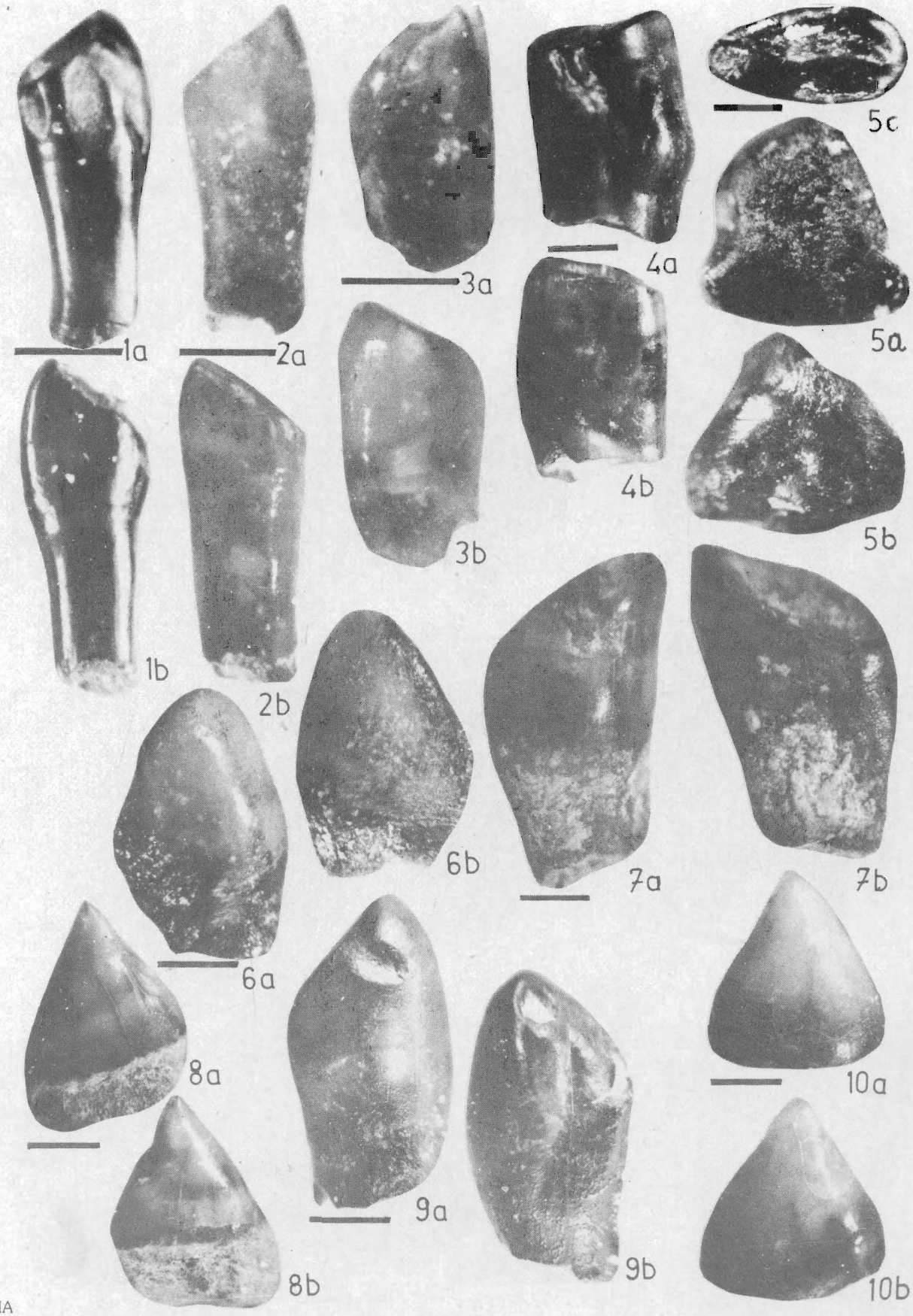
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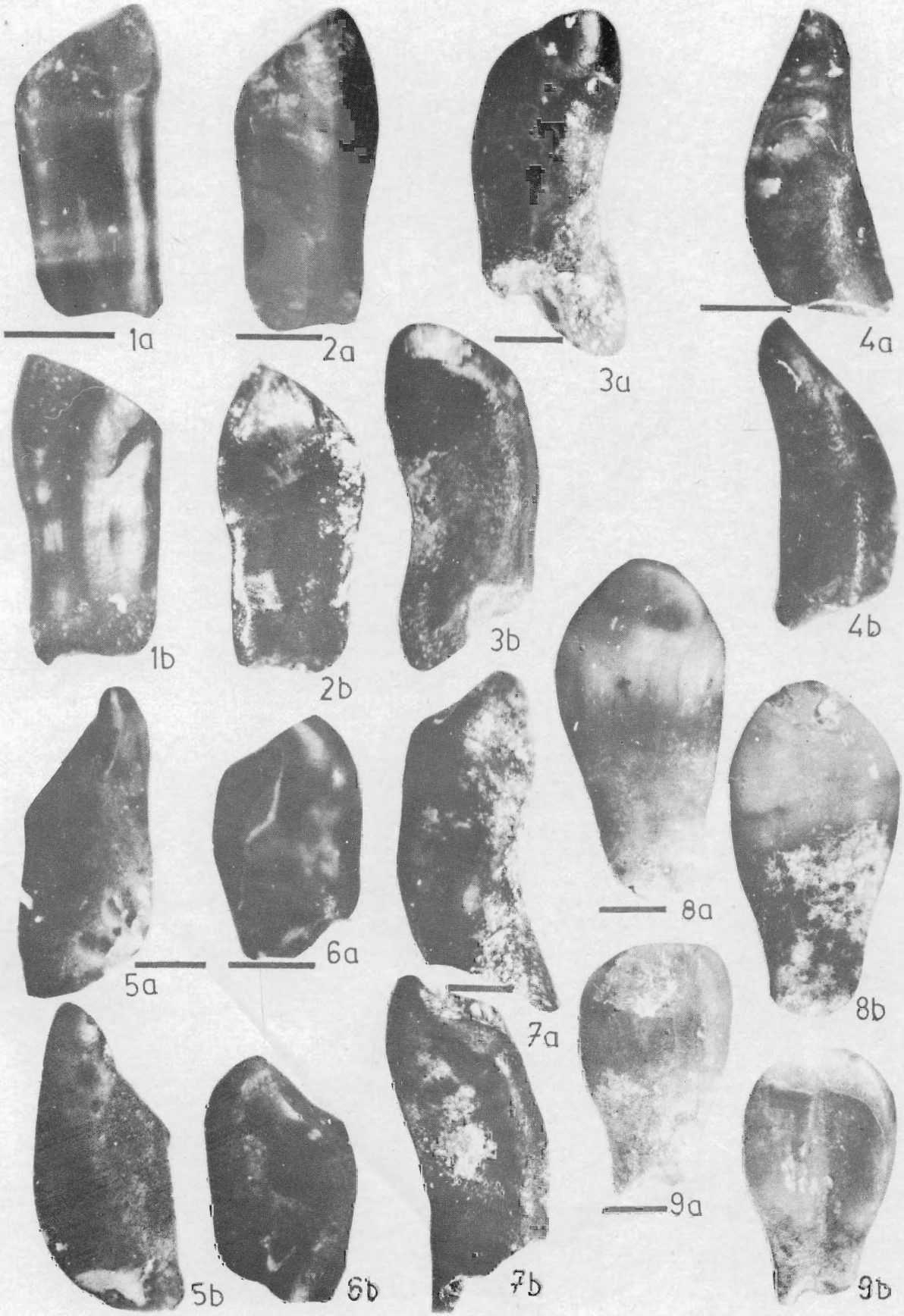
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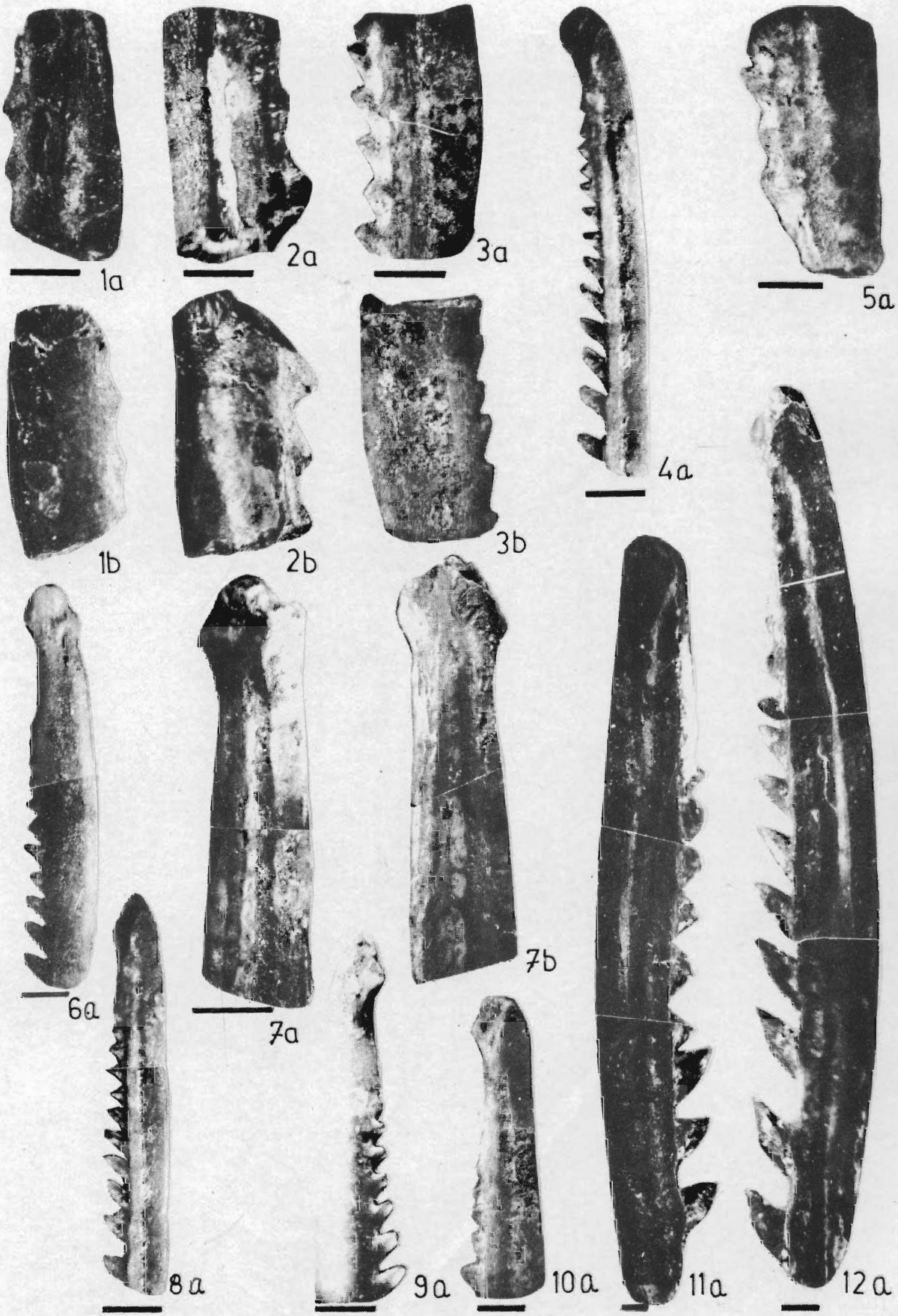
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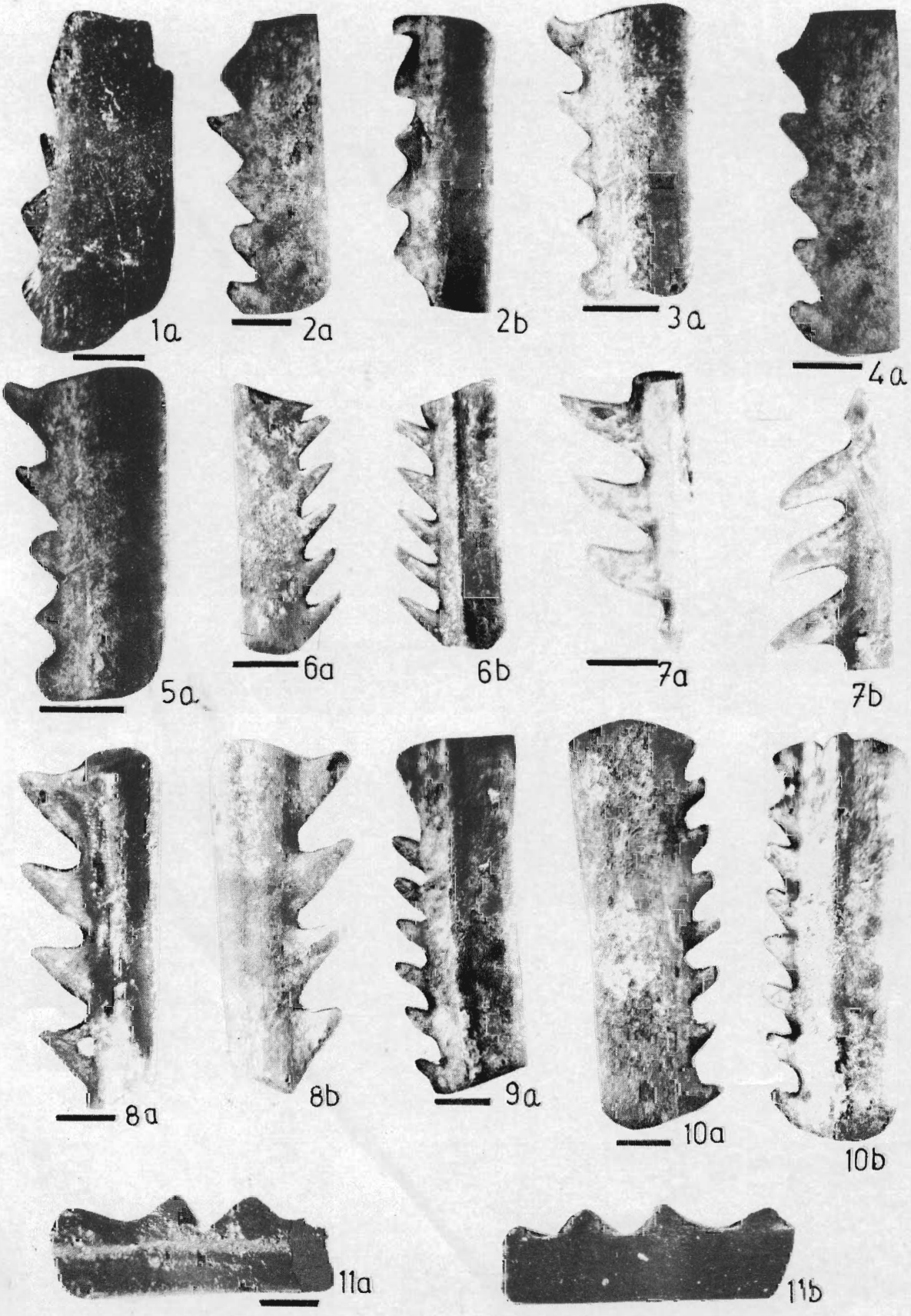
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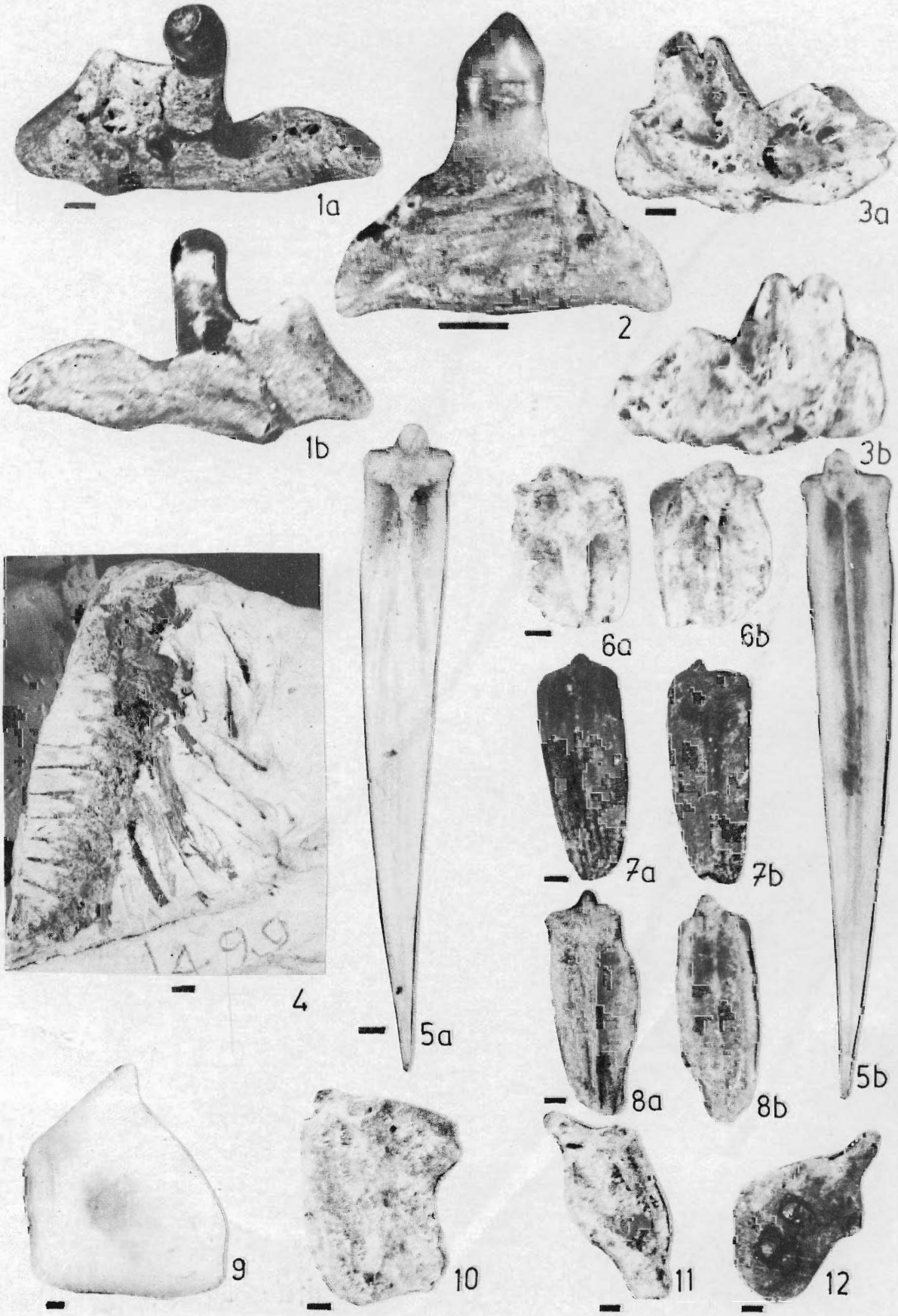
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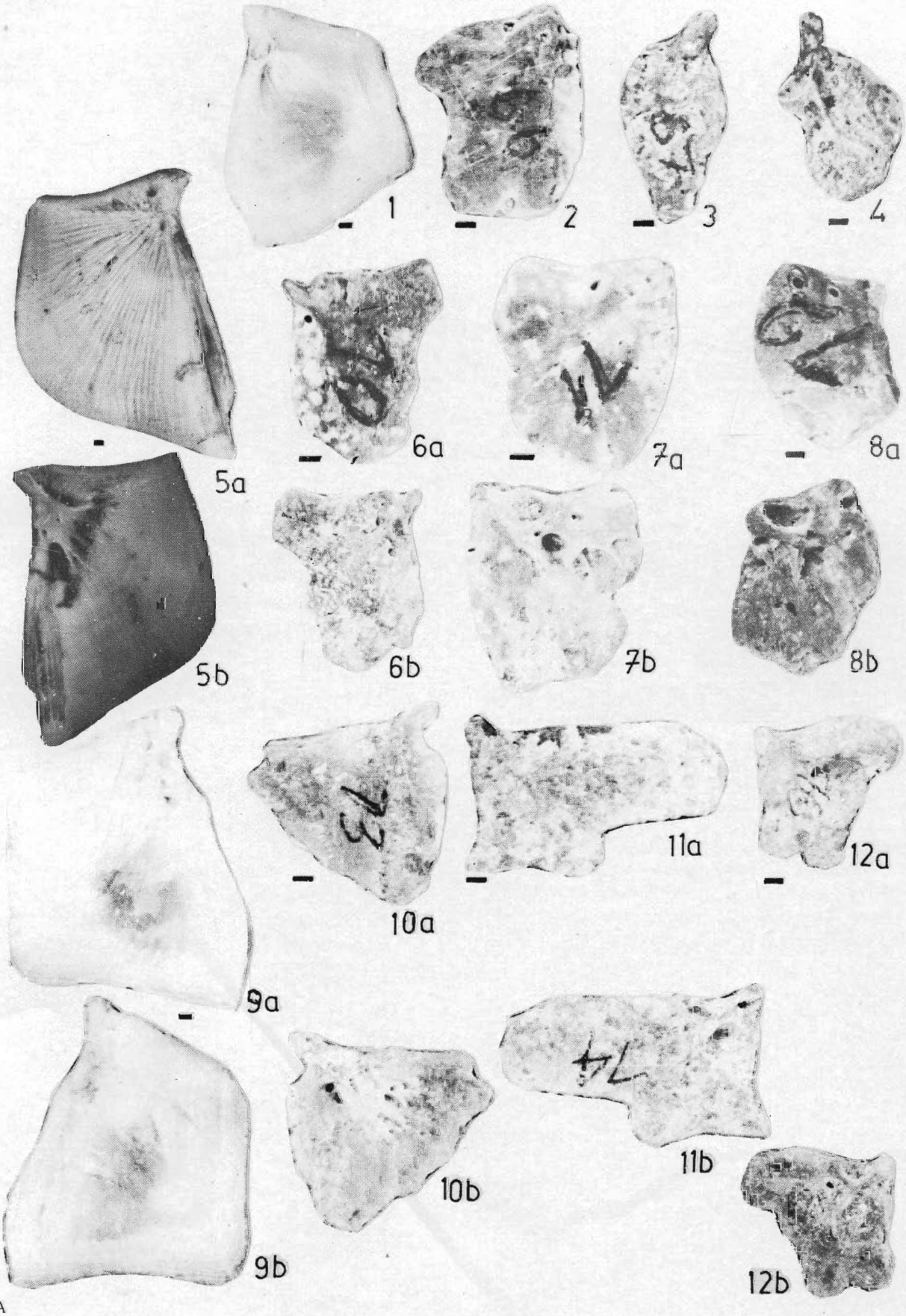
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