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Extra Ossicles in the Oral Region on Three Species of *Bleekeria* (Ammodytidae)

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Abstract Extra ossicles found in the oral region of *Bleekeria vaga* are described and illustrated in detail. They are ossified cartilaginous parts of the ligaments or ligamentous structures connecting the following bones and membranes; posterior ends of the maxillary and premaxillary to the anterior end of the dentary; the maxillary to the coronoid process of the dentary; the maxillary to the vomer; articular process of the premaxillary to the maxillary; and the articular process of the premaxillary to the tip of the rostral cartilage.

Similar ossicles are also found in *B. gilli* and *B. renniei*. Corresponding cartilaginous structures in *B. viridianguilla*, *Embolichthys mitsukurii*, *Ammodytes personatus*, and *A. hexapterus* are not ossified.

Among the fishes of the family Ammodytidae, *B. vaga* and *B. gilli* seem to have the most protrusile mouth, and the presence of the ossicles seems to have to do with the marked protrusibility of the upper jaw. These ossicles ase also absent in fishes of the Hypoptychidae and Trichonotidae, to which the family Ammodytidae was once considered to be related.

Introduction

Gosline (1963) noted: "The upper jaw of *Bleekeria* is essentially similar to that of *Ammodytes* except that a number of small ossicles are to be found in the ligamentous tissues connected with the jaw apparatus. Thus there is an ossicle above more lateral of the two pedicels of the premaxillary, another at the distal end of the premaxillary, and a whole series in the ligamentous tissue that runs between the upper and lower jaws." Because Gosline's interest was focused on comparative morphology of perciform families with elongate body, he did not discuss the extra bones of *Bleekeria* in detail and no illustration was presented. As far as I am aware, however, his account seems to be the first record of this peculiar structure in *Bleekeria*. The ossified ligament between the premaxillary and maxillary in some species of the *Pellona*, Clupeoforms (Bleeker, 1872: 117; Weber and Beaufort, 1913: 86, fig. 29) is another example of the extra bone in the oral region. This report aims to describe the structure of the ammodytid oral region in detail.

Materials

The following specimens were observed. (*Bleekeria gilli* and *B. renniei* were examined on radiographs of their type series.)

Ammodytidae

Bleekeriinae

Bleekeria vaga McCulloch and Waite: Australian Museum I. 9272, holotype, standard length 150 mm, from Lord Howe I.
A. M. IB. 3241, S. L. 54.5 mm, from New South Wales, stained with alizarin red S.

B. gilli Bean: American Museum Natural History, syntypes, 8 specimens, S. L. 88～116 mm, type locality not known (radiographs).

B. renniei Smith: Rhodes University J. L. B. Smith Institute, RUSI 174 and 670, S. L. 59 and 60 mm, type locality near East London, (radiographs).

B. viridianguilla Fowler: 5 specimens S. L. 66～138 mm, from Pescadores Is., Formosa.

Embolichthys mitsukurii (Jordan and Evermann): 3 specimens, S. L. 66～155 mm, from Pescadores Is.

Ammodytinae

Ammodytes personatus Girard: 10 specimens, S. L. 22～130 mm, from Kanagawa prefecture, beach seine.

A. hexapterus Pallas: 8 specimens, S. L. 95～116 mm, from Bristol Bay, stomach contents of *Platichthys stellatus*.

Observations

The extra ossicles in *Bleekeria vaga*, *B. gilli*, and *B. renniei* replace cartilaginous tissues in the ligaments of the oral region of other ammodytids. Before describing these extra ossicles, the cartilages within some ligaments in the oral region of *Embolichthys mitsukurii*, *Bleekeria viridianguilla*, and *Ammodytes hexapterus* are described (Fig. 1). The term anterior or posterior and dorsal or ventral mean the position when the mouth is closed.

Embolichthys mitsukurii

1. Labial ligament (including cartilage I): slender ligament connecting anterior tip of the dentary with the posterior end of the maxillary through the posterior end of the premaxillary. When the mouth is closed, this cartilage is straightened just below the biting edge of the premaxillary.

2. Accessory labial ligaments 1～6 (including accessory labial cartilages 1 4): short and conical ligaments attaching perpendicularly the cartilage I when the mouth is fully open. When the mouth is closed these ligaments are folded parallel to the cartilage I. Thus all of the accessory labial ligaments are enforcing and fixing the position of the labial cartilage against the backward tension of the whole lower lip when the mouth is fully open. The posterior two accessory labial ligaments, aclb 5, 6, lack the cartilage.

3. Maxillo-dentary ligament (including cartilage II): connecting posterior end of the maxillary with upper tip of coronoid process of the

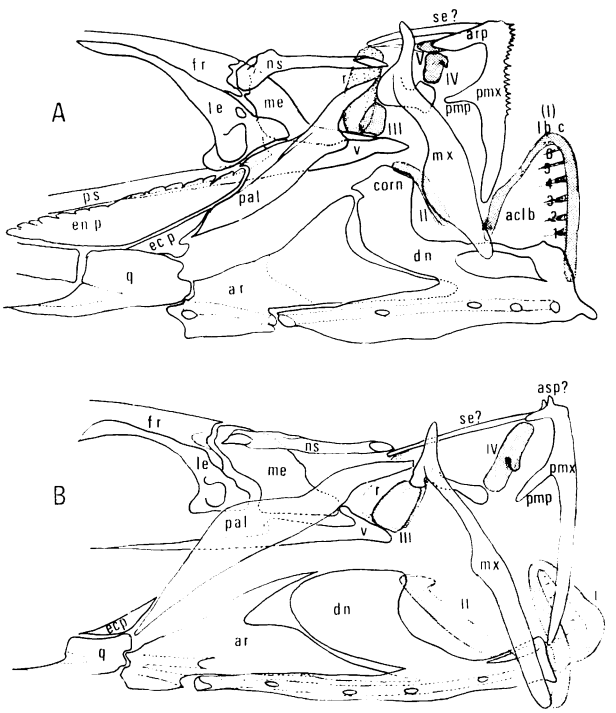

Fig. 1. Head skeletons of *Embolichtys mitsukurii*, 115 mm in standard length (A) and *Ammodytes hexapterus*, 108 mm (B). Stippled areas represent cartilage. aclb: accessory labial ligament, ar: articular, arp: articular process of premaxillary, asp: ascending process of premaxillary, corn: coronoid process of dentary, dn: dentary, ecp: ectopterygoid, en: endopterygoid, fr: frontal, le: lateral ethmoid, me: mesethmoid, mx: maxillary, ns: nasal, pal: palatine, pmp: post maxillary process of premaxillary, pmx: premaxillary, ps: parasphenoid, q: quadrate, r: rostral cartilage, se: supraethmoid, v: vomer, I: labial cartilage, II: maxillo-dentary cartilage, III: maxillo-vomerine cartilage, IV: maxillo-premaxillary cartilage, V: prerostral cartilage.

dentary. When the mouth is closed this cartilage lies obliquely under the nasal.

4. Maxillo-vomerine ligament (including cartilage III): oval shaped ligament connecting the dorsal condyle of the maxillary with the dorsal surface of the vomer. This ligament moves slightly when the mouth is opened or closed.

5. Maxillo-premaxillary ligament (including cartilage IV): elongated oval-shaped ligament connecting ventral condyle of the maxillary with dorso-posterior surface of the articular process of the premaxillary. The cartilage IV has a small, conical process laterally and another small ligament connects tip of this process with the membrane between the premaxillary and maxillary. The cartilage IV is thus fixed laterally by this process.

6. Premaxillo-rostral ligament (including cartilage V); conical ligament connecting articular process of the premaxillary with the posterior tip of the long rostral cartilage. This ligament is always parallel to the ascending part of the premaxillary, and the cartilage V lies just under the anterior part of the nasal when the mouth is closed.

Bleekeria viridianguilla

There is no difference in number and position of ligaments of the oral region between *Bleekeria viridianguilla* and *Embolichthys mitsukurii*.

Ammodytes hexapterus

Ammodytes hexapterus lacks the ligament connecting articular process of the premaxillary with the rostral cartilage, and the accessory labial cartilages.

The accessory labial ligaments themselves are present in *A. hexapterus* in the same number as in *E. mitsukurii*. In other respects the cartilages in the ligaments of the oral region in *A. hexapterus* (Fig. 1B) is similar to those of *E. mitsukurii*.

Bleekeria vaga

In *Bleekeria vaga*, all the cartilages of *Embolichthys mitsukurii* are substituted by a number

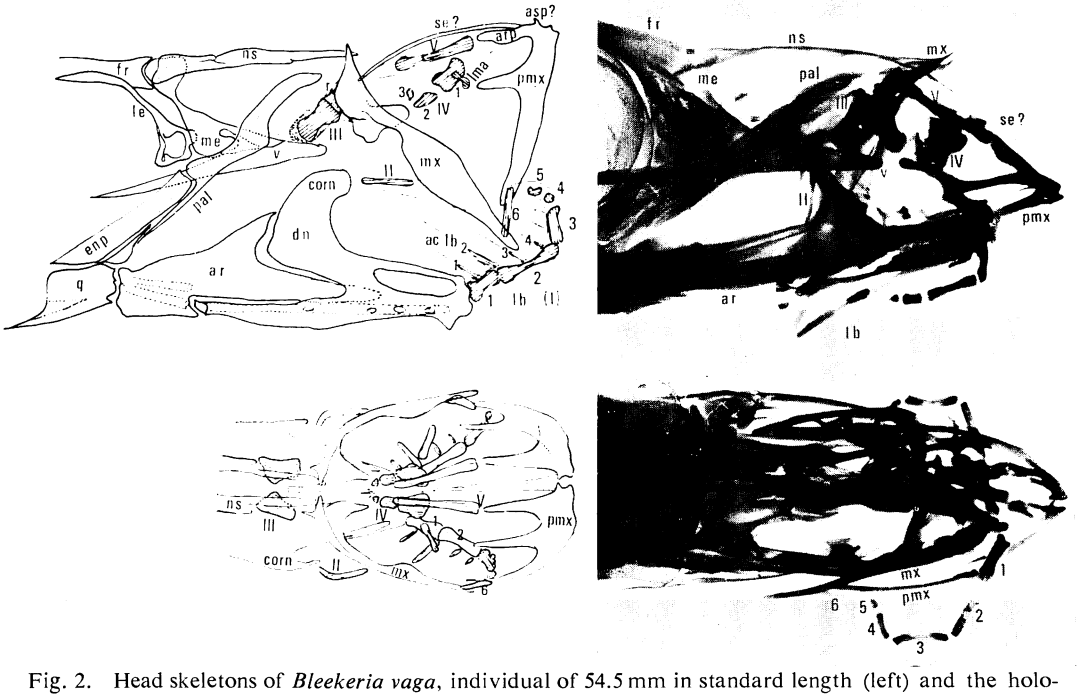

Fig. 2. Head skeletons of *Bleekeria vaga*, individual of 54.5 mm in standard length (left) and the holotype, 150 mm (right). Degree of protrusion of two individuals is slightly different. Upper, lateral view; lower, dorsal view. aclb: accessory labial ossicles 1-4 (from anterior), lma: lateral maxillo-premaxillary ossicle, 1b=I: labial ossicles 1-6 (from anterior), II: maxillo-dentary ossicle, III: maxillo-vomerine ossicle, IV: maxillo-premaxillary ossicles 1-3 (from anterior), for other abbreviations see Fig. 1. Dashed area represent ossicles found in *Bleekeria vaga*.

of ossicles (Fig. 2). The following names are proposed to these ossicles.

1. Labial ossicles 1～6: ossified equivalent to the labial cartilage of *Embolichthys mitsukurii*, divided into six ossicles. They are the chain of six bones, elliptical and cylinder-shaped except the last (1b 6) which is rod-shaped and the longest. The anterior three ossicles (1b 1～3) are constricted at the center. The first ossicle bears the first accessory labial ligament which includes another ossicle. The second ossicle is the largest in this chain of ossicles, and bears the second, third and fourth accessory labial ligaments each of which contains an ossicle. The third labial ossicle is semiequal to the first in its length and bears two small accessory labial ligaments which are neither cartilaginous nor bony. The fourth and fifth labial ossicles are the smallest of the series and situate at the turning point of the whole labial ligaments when the mouth is fully protruded. The sixth ossicle lies between posterior ends of the premaxillary and the maxillary, uniform rod and sub-equal to the second labial ossicle in its length.

2. Accessory labial ossicles 1～4: minute bones associated with the labial ossicles 1 and 2. The first accessory labial ossicle attaches to the first labial ossicle and the following three acces-

Table 1. Ossicles found in the oral region of *Bleekeria vaga*. Names of equivalent parts in Kayser's (1962) term are shown in parentheses.

Ossicles	Location of ossicles	Location of ligaments	Function of ligaments and remarks
Labial ossicles 1-6.	Labial ligament (Ligamentum maxillomandibulare anterius)	Lower lip: distal end of the maxillary and that of the premaxillary to tip of the dentary	Enforcement of lip
Accessory labial ossicles 1-4	Accessory labial ligaments 1-4 (not shown in Kayser)	Just behind the labial ossicles 1 and 2	Supporting perpendiculary labial ossicles
Maxillo-dentary ossicle	Maxillo-dentary ligament (Ligamentum maxillo-mandibulare mediale)	Between coronoid process of the dentary and posterior part of the maxillary	Fastening posterior part of the maxillary to the dentary
Maxillo-vomerine ossicle	Maxillo-vomerine ligament (Cranialar Gelenkknorpel des Maxillare)	Between the dorsal condyle of articular process of maxillary and the dorsal surface of the vomer	Fastening and supporting the premaxillary to the vomero-ethmoid region
Maxillo-premaxillary ossicle 1-3	Maxillo-premaxillary ligament (Gelenkknorpel zwischen Maxillare und Premaxillare)	Between the articular process of the premaxillary and ventral condyle of the maxillary	Articulating and supporting the articular process of the premaxillary and the prerostral ossicle
Lateral maxillo-premaxillary ossicle	Lateral maxillo-premaxillary ligament (lateral projection of "Gelenkknorpel")	Perpendicular projection of the maxillo-premaxillary ligament	Fastening perpendicularly the maxillo-premaxillary ossicle 1 to oral membrane
Prerostral ossicle	Premaxillo-rostral ligament (absent in *Ammodytes*)	Between the articular process of premaxillary and top of the rostral cartilage	Reinforcing the upper part of upper jaw in protrusile movement, slides the dorsal surface of the maxillo-premaxillary ossicle 1. Paralleling "ascending part of the premaxillary".

sory labial ossicles (ac 1b 2-4) attach to the second labial ossicle.

3. Maxillo-dentary ossicle: ossified equivalent to cartilage II of *Embolichthys mitsukurii*, cylinder-shaped and its anterior tip crooked. When the mouth is closed, it rests on the coronoid process of the dentary.

4. Maxillo-vomerine ossicle: reel- or windlass-shaped ossicle, lying on the anterior part of the vomer and supporting the dorsal condyle of the premaxillary when the mouth is protruded.

5. Maxillo-premaxillary ossicles 1-3: ossified equivalent to the cartilage IV of *E. mitsukurii*, divided into three ossicles. The first ossicle is the largest and supporting articular process of the premaxillary and the following prerostral ossicle when the upper jaw is protruded. The second and third maxillo-premaxillary ossicles are small and intervening between the first maxillo-premaxillary ossicle and the ventral condyle of the maxillary. When mouth is closed the first maxillo-premaxillary ossicle is folded on the anterior surface of the ventral condyle of the maxillary, thus the whole maxillo-premaxillary ligaments bend at the part of the second and the third maxillo-premaxillary ossicles.

6. Lateral maxillo-premaxillary ossicle: ossified equivalent to the lateral process of the cartilage IV of *E. mitsukurii*, fixing the first maxillo-premaxillary ossicle associated with the ligament to the membrane between the premaxillary and the maxillary.

7. Prerostral ossicle: ossified equivalent to the cartilage V of *E. mitsukurii*, enforcing the thin, flexible ascending part of the premaxillary. When the mouth is opened, this prerostral ossicle slides together with the articular process of the premaxillary over the dorsal surface of the first maxillo-premaxillary ossicle.

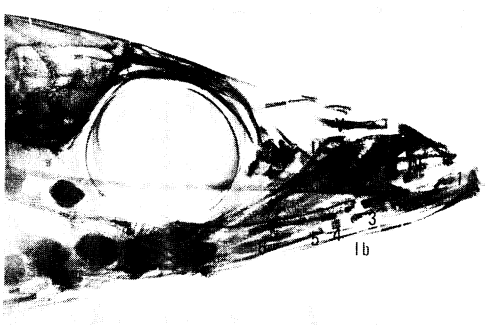

Fig. 3. Head region of *Bleekeria gilli*, one of the syntypes. Irregular shadows of branchial region are sand grains. For abbreviations see Fig. 1.

Locations and functions of these ossicles are summarized in Table 1.

Bleekeria gilli and *B. renniei*

Almost the same ossicles are observed on radiographs in all individuals of the syntypes of *Bleekeria gilli* (Fig. 3) and the paratypes of *B. renniei*. The ossicles, however, around the ethmoid region are not obvious on radiographs. As it can be seen from this figure, the position and the number of ossicles in each ligament are same but the relative sizes of each ossicle are slightly different between *B. vaga* and *B. gilli*.

Discussion

Most species of the family Ammodytidae have cartilaginous structures with ligaments around the oral region. The ossicles of the oral region of *Bleekeria vaga* and *B. gilli* apparently originated from the cartilages.

Labial ligament is folded when the mouth is open, whereas the maxillo-premaxillary ligament is folded when the mouth is closed in *Embolichthys mitsukurii*. Ossicles of these two ligaments in *Bleekeria vaga*, *B. gilli*, and *B. renniei* are numerous and cartilaginous parts intervene between them, so as to give both the flexibility and rigidity. Cartilage V (Fig. 1A) moves straightly and cartilage II rotates in the same plane, and III moves very slightly when the mouth is opened. Ossicles of these three cartilages are each represented by a single ossification.

The extra ossicles contribute to strengthen the oral part. The ossification of cartilages of the oral region seem to occur in relation to the developement of protrusility of the upper jaw. The reason why the ossicles are confined only in some fishes of *Bleekeria* among the family Ammodytidae is, at present, uncertain.

The ratio of length of the ascending part of the premaxillary against that of the premaxillary proper is assumed to reflect the degree of protrusility (Table 2).

Because the species with the ossicles, *Bleekeria vaga*, *B. gilli*, and *B. renniei*, have the high ratio, they may be regarded to have more pro-

Table 2. Comparison of the protrusility of the upper jaw in the Ammodytidae.

	Bleekeria viridianguilla	*Ammodytes personatus*	*Ammodytes hexapterus*	*Embolichthys mitsukurii*	*Bleekeria gilli*	*Bleekeria vaga*
Standard length (mm)	113	141	108	114	ca 96	54.5
Length of the premaxillary (A) (mm)	5.6	6.8	6.0	5.6	5.9	2.80
Length of the ascending part of the premaxillary (B) (mm)	2.8	4.1	4.3	4.1	5.7	2.80
Protrusility index B/A (%)	50	60	71	73	97	100
Presence or absence of ossicles	−	−	−	−	+	+

trusile mouth than others. It may be said that the ossification of the ligamentous structures of the oral region occurs in members having marked protrusile mouth among this family.

The nature of the ascending part of the premaxillary and also the mechanism of upper jaw protrusion need further study. These points will be discussed in my next paper.

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イカナゴ類の *Bleekeria* 属三種の口部の小骨片について

井田　斉

豪州東部海域に分布する *Bleekeria vaga* の下唇，及び前上顎骨—上顎骨，上顎骨—歯骨，上顎骨—鋤骨を結ぶ紐帯中に軟骨起源の小骨片が多数認められた．同様の小骨片は *Bleekeria gilli* および *B. renniei* にも認められた．イカナゴ *Ammodytes personatus*，タイワンイカナゴ *Embolichthys mitsukurii*，*Bleekeria viridianguilla* などのイカナゴ科魚類の該当部位には軟骨組織が発達しているが骨化は認められなかった．軟骨組織や骨組織が発達することにより口部の構造は強化されるが，この構造の強化はイカナゴ類の食性と上顎の著しい伸出性に関連していると考えられる．

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