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# Distribution of Taste Buds in the Oropharyngeal Cavity of Larval and Juvenile Stages of the Cyprinid Fish, *Tribolodon hakonensis*

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It is well known that most fishes have specialized taste organs in the epidermis of the lips, mouth and pharynx, and over the surface of the head and trunk (Iwai, 1964; Atema, 1971; Kiyohara et al., 1980; Ezeasor, 1982; Hamed et al., 1984; Finger et al., 1991; Komada, 1993). However, the development and changes in distribution patterns of taste buds during fish growth have not been studied in detail. In this paper, changes in the distribution patterns of taste buds and their size and number in the oropharyngeal cavity were studied in relation to growth in the cyprinid fish, *Tribolodon hakonensis*.

## Materials and Methods

The dace, *Tribolodon hakonensis*, used for histological examination in this study were obtained from a hatchery ($n=40$) and the Nagara River ($n=3$) in 1991. The hatchery fish ranged in age from 1 to 150 days after hatching and in total length (TL), from 6.8 to 36.0 mm, including 1-day old (6.8–7.2 mm TL), 2-day old (7.0–7.8 mm TL), 3-day old (8.0–9.0 mm TL), 4-day old (8.5–9.5 mm TL), 5-day old (9.0–10.3 mm TL), 25-day old (14.0–16.0 mm TL), 90-day old (23.0–24.0 mm TL) and 150-day old (34.0–36.0 mm TL). Total lengths of the Nagara River specimens were 10.0, 14.0 and 35.0 mm. The head of each specimen was removed, fixed with Bouin's solution, and subsequently decalcified, dehydrated and embedded in paraffin. The heads were sectioned (7 $\mu$m thickness) and stained with Mayer's hematoxylin and eosin.

The contents of the digestive tracts of 8.5–10.0 mm TL ($n=50$), 14.0–16.0 mm TL ($n=50$) and 34.0–36.0 mm TL ($n=50$) specimens, also collected from the Nagara River in 1991, were examined microscopically.

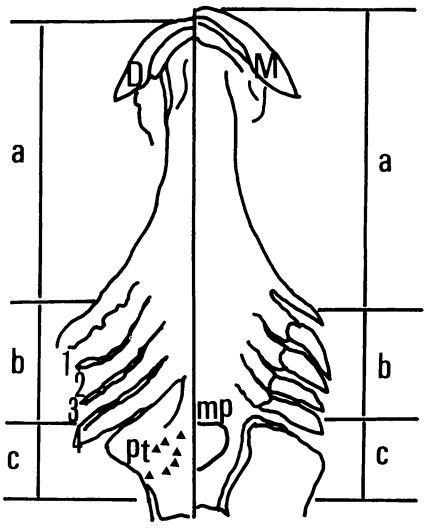


**Fig. 1.** Schematic illustration showing the oropharyngeal cavity of *Tribolodon hakonensis*. *Left*—ventral surface; *right*—dorsal surface; *a*—oral region; *b*—branchial region; *c*—pharyngeal region; *M*—maxillary; *D*—dentary; *mp*—masticating plate; *pt*—pharyngeal teeth; *1–4*—number of each gill arch.

## Results and Discussion

In one-day old specimens, no taste buds were observed in the oropharyngeal cavity. On the second day after hatching (2-day old fish), localized groups of cells were identified among the stratified cells in the surface epithelium of the gill arch, tongue and palate. At age 3–5 days, the intra-epithelial cell groups had differentiated further from the surrounding cells on the tongue, lips, gill arches, pharynx, palate and other parts of the oropharyngeal cavity. The distribution of taste buds in the oropharyngeal cavity of post-larval fish (5-day old) was basically similar to that of 90-day old specimens (Figs. 1–4).

The total number of taste buds in the oropharyngeal cavity was about 25 at age 2 days, 103 at 3 days, 452 at 4 days, 507 at 5 days, 1109 at 25 days, 3009 at 90 days and 3200 at 150 days. The marked increase in number of taste buds in each of the observed regions at 4–5 days of age (9.5–10.3 mm TL) coincided with the complete absorption of the yolk. The average density of taste buds overall in the oropharyngeal cavity increased progressively during the first 25 days after hatching but became significantly lower in 90-day old fish (Figs. 2–4). Both the distribution patterns and numbers and densities of taste buds in

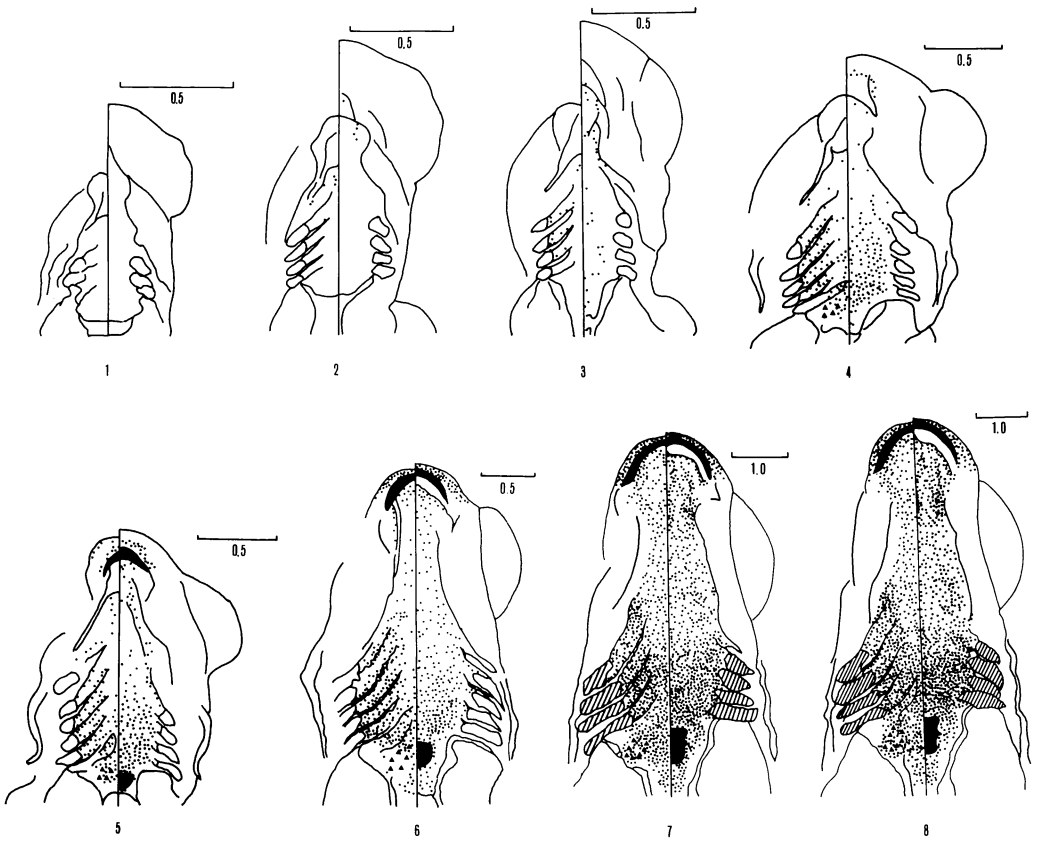


**Fig. 2.** Distribution of taste buds (small dots) and pharyngeal teeth (triangles) in the oropharyngeal cavity of hatchery-reared *Tribolodon hakonensis*. *1*—1 day old; *2*—2 days old; *3*—3 days old; *4*—4 days old; *5*—5 days old; *6*—25 days old; *7*—90 days old; *8*—150 days old. Solid black indicates cornified layer. *Left*—ventral surface; *right*—dorsal surface; scale in mm.

the juvenile fish from the Nagara River (Fig. 5) were similar to those in the hatchery-reared fish. The changes with growth of taste bud densities in the oropharyngeal cavity of *Tribolodon hakonensis* were essentially similar to those in *Oncorhynchus rhodurus* (Komada, 1993) and on the fins and body surface of *Ictalurus punctatus* (Finger et al., 1991).

The 25-day old fish had about 44.0 times the number of taste buds in 2-day old fish, the surface area of the oropharyngeal cavity in the former being about 6.0 times that of the latter. Subsequently, the number of taste buds in 90-day old fish was about 2.7 times that of larval fish (25-day old), the surface area in the former being about 4.5 times that of latter. These results suggest that the increase in taste bud densities between 2 and 25 days of age (larval stage) may be influenced considerably by the increase in the number of taste buds, and the reduction in densities between 25 and 90 days of age (young stage) may largely result from the increase in oropharyngeal cavity surface area.

In 9.0–36.0 mm TL (5–150 days old), hatchery-reared specimens, high taste bud densities were observed on the lips, gill apparatus (gill arches and gill rakers), pharynx and palatal organ. However, no taste buds were found on the anterior portion of the inner labia oris or on the masticating plate. Gill rakers, present in 150-day old (34.0–36.0 mm TL) specimens, were not observed in younger (1–90 days old, 8.0–24.0 mm TL) fish.

In 4-day old larval fish (9.0 mm TL), the highest densities of taste buds were found on the gill arches ($>382\,mm^{-2}$) and palatal organ (roof of branchial cavity) ($>747\,mm^{-2}$). The corresponding densities

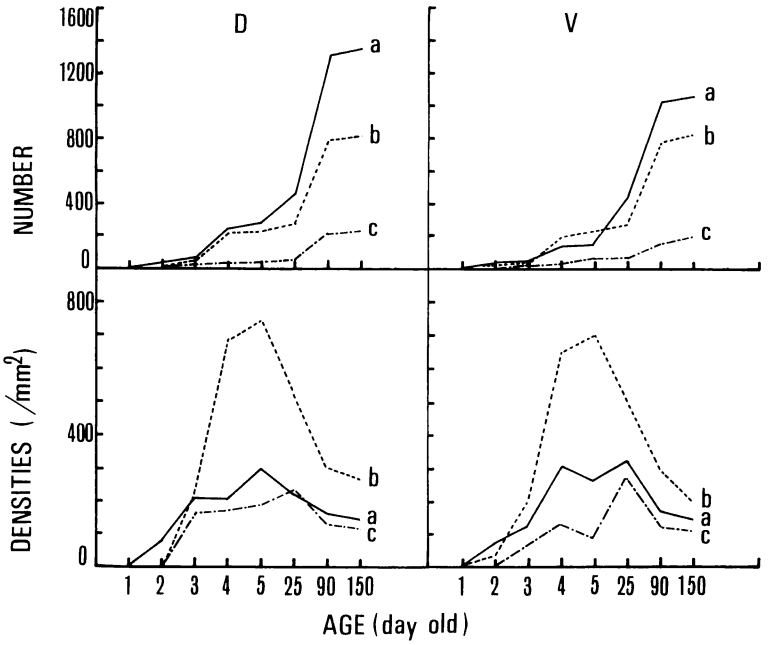


**Fig. 3.** Numbers and densities of taste buds in the oropharyngeal cavity of hatchery-reared *Tribolodon hakonensis*. *a*—oral region; *b*—branchial region; *c*—pharyngeal region; *D*—dorsal surface; *V*—ventral surface.

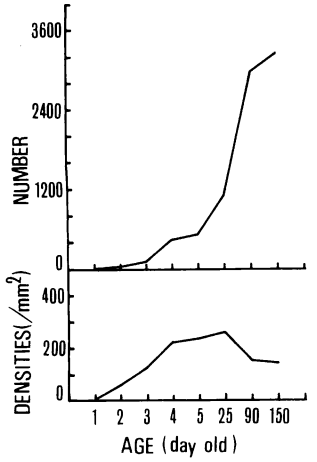


**Fig. 4.** Total numbers and overall densities of taste buds in the oropharyngeal cavity of hatchery-reared *Tribolodon hakonensis*.

in a 150-day old (35.0 mm TL) fish were $>191$ and $>315\,mm^{-2}$.

These observations disclosed that the great majority of taste buds were located on the lips and inside the mouth, the highest densities in larval and juvenile fish occurring on the lips, gill arches and palatal organ. Taste buds were also scattered over the outer skin of the head. The early differentiation and wide distribution of taste buds in the oropharyngeal cavity is indicative of the great importance of this organ in cyprinids. This is particularly so during the larval stage, the taste bud densities in the oropharyngeal cavity being clearly higher than in young fish. The densities of taste buds in the gill arches and gill rakers of young *T. hakonensis* were comparable to those of other cyprinid fishes, *Biwia zezera*, *Cyprinus carpio* and *Carassius auratus* (Iwai, 1964). Furthermore, the densities and distribution patterns of taste buds in the oropharyngeal cavity of *T. hakonensis* (35.0 mm TL) were similar to those of *Pseudorasbora parva* (50–70 mm TL) (Kiyohara et al., 1980).

Taste buds were oriented perpendicularly on the surface of the epithelium of the lips and palatal organ. The epithelial layer in the oral, branchial and pharyngeal cavity was usually thicker in older fishes resulting in the taste buds being more elongated in such fish. Figure 6 shows that the taste buds increase both in height (especially) and diameter with fish growth.

The taste buds in the oropharyngeal cavity were

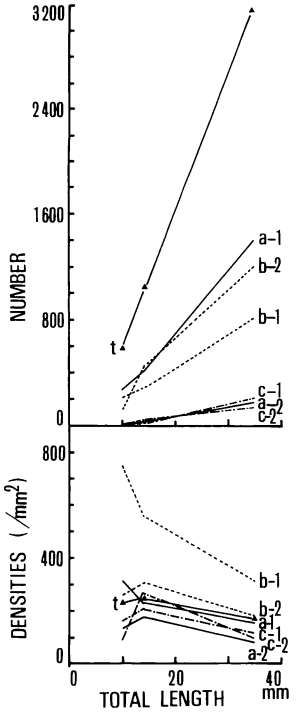


**Fig. 5.** Numbers and densities of taste buds in the oropharyngeal cavity of *Tribolodon hakonensis* collected from the Nagara River in 1991. *a*—oral region; *b*—branchial region; *c*—pharyngeal region; *1*—dorsal surface; *2*—ventral surface; *t*—total.

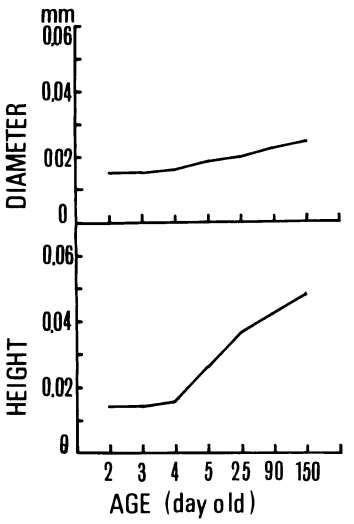


**Fig. 6.** Height and maximum diameter of taste buds on the roof of the branchial cavity (palatal organ) of *Tribolodon hakonensis*.

ovoid in larval fish. Primordial taste buds were first detected in the pharynx, 3 days after hatching. Subsequently, the number of epidermal elevations (papillae usually containing a single taste bud) in the pharynx increased with fish growth. The papillae were arranged in rows on the ridges between the lower throat denticles. Taste buds were found neither on a horny (cornified) pad lying on a ventral projection of the basioccipital (demonstrated histologically in larvae 9.0–13.0 mm TL), nor on the anterior portion of the inner lips of larval, juvenile and young specimens, possibly because the surface cells of the epithelium in the latter region had become cornified during the larval stage (8.5–9.5 mm TL, 4

**Table 1.** Size of natural food items found in the digestive tract of *Tribolodon hakonensis* collected from the Nagara River in 1991 ($n=50$)

| Contents | Total length of fish (mm) | | | | | |
|---|---|---|---|---|---|---|
| | 10–12 | | 14–16 | | 34–36 | |
| | *n* | % | *n* | % | *n* | % |
| Aquatic insects | | | | | | |
| Chironomidae | | | | | | |
| larvae head width | | | | | | |
| (0.08–0.10 mm) | 24 | 48.0 | 0 | 0.0 | 0 | 0.0 |
| (0.10–0.15 mm) | 42 | 84.0 | 10 | 20.0 | 5 | 10.0 |
| (0.15–0.20 mm) | 0 | 0.0 | 40 | 80.0 | 36 | 72.0 |
| (0.20–0.30 mm) | 0 | 0.0 | 10 | 20.0 | 40 | 80.0 |
| pupae | 0 | 0.0 | 29 | 58.0 | 35 | 70.0 |
| undetermined | 8 | 16.0 | 14 | 28.0 | 18 | 36.0 |
| Larval fish | 0 | 0.0 | 0 | 0.0 | 2 | 10.0 |
| Algae | 50 | 100.0 | 33 | 66.0 | 16 | 32.0 |

days old).

*T. hakonensis* is an active, non-benthic inhabitant of freshwater rivers and lakes, feeding on small benthic organisms, plankton, fishes and vegetable matter during the larval and adult stages. 8.5–10.0 mm TL fish swim near the surface in stagnant regions, with 14.0–16.0 mm TL fish occurring in river shallows. The head width of aquatic insects contained in the digestive tracts of 8.5–10.0 mm TL fish were clearly smaller than those found in 14.0–16.0 mm TL and 34.0–36.0 mm TL fish, all being collected from the Nagara River in 1991 (Table 1). It is conceivable that the fish masticate and pierce potential prey or other food items with the lower throat denticle, ingestion or rejection of the former following stimulation of the adjacent taste buds. The results of this study suggest that the distribution patterns and densities of taste buds and their close association with the pharyngeal teeth may reflect the gustatory feeding mode of *T. hakonensis*, as well as the ecological conditions under which the fish live.

## Acknowledgments

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## ウグイ仔・稚魚の口腔–咽頭内における味蕾の分布

駒田格知

人工孵化ウグイ仔・稚魚の口腔–咽頭における味蕾の分布，数，密度および大きさについて調べた．さらに，長良川にて採補したウグイ稚魚についても同様の調査を行って比較した．

孵化後2日目（2日齢）のウグイ仔魚の口腔底，鰓弓および口蓋部に味蕾の初期と思われる細胞の集団が初めて認められた．味蕾数および分布域はその後の日齢の進行に伴って急激に増大した．そして，5日齢に達すると分布域は若魚の場合とほぼ同様となり，密度も著しく増大した．卵黄の吸収はこの頃にほぼ完了した．その後，25日齢頃までは味蕾数は増加したが，密度はほぼ同程度に維持された．しかし，その後，密度は減少した．口唇の内側および咽頭歯に対応する咽頭上壁の上皮細胞は5日齢頃から角化が進行し，日齢の進行に伴って上皮層の厚さを増すが，この部位に味蕾の分布は確認されなかった．味蕾の分布密度は鰓腔の天井部（口蓋器）で特に高く，さらに口唇部およびその後方部においても高かった．この傾向は卵黄吸収完了前にすでに確認され，その後も維持された．なお，長良川において採捕されたウグイ稚魚の味蕾の分布，数および密度は，同じ体長の人工孵化ウグイの場合と同様であった．

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