Second record of *Eukrohnia kitoui* (Chaetognatha) with notes on morphological differences from the closely related *E. calliops*

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Received 7 July 2013; Accepted 20 September 2013

**Abstract:** Nine specimens of the planktonic chaetognath *Eukrohnia kitoui*, which was originally described from Tokyo Bay 32 years ago, were collected from an underwater canyon in Tosa Bay, Japan. This is the second record of the species. We compared *E. kitoui* and the closely allied *E. calliops* based on individual data of the two species reported in the previous and the present studies. Since allometric growth was observed in morphometric characters, specimens smaller than 10 mm in body length were omitted in this comparison. The results revealed that the ratios of tail segment and eye lengths to body length and the numbers of hooks and posterior teeth on the head, which were described as distinguishable features between the species in the previous study, were significantly different between the species. However, the values of these characters overlapped between the species except for the eye/body ratio, indicating that the eye size is the most critical feature distinguishing them. The present specimens showed that the relative position of the transverse musculature to the ventral ganglion, which was another diagnostic character of *E. kitoui* in the previous study, varied greatly according to growth. Considering the characteristic sampling sites (underwater canyons) and a long absence of occurrence records, *E. kitoui* is probably a rare species restricted to waters in or near coastal underwater canyons, as observed in *E. calliops*.

**Key words:** allometric growth, chaetognaths, *Eukrohnia kitoui*, Tosa Bay, underwater canyon
McLelland (1989) described *Eukrohnia calliops* McLelland, 1989 from near the bottom at 677 m depth in the Gulf of Mexico. Since *E. calliops* is morphologically very close to *E. kitoui*, he compared the two species based on specimens; the specimens of *E. kitoui* from Tokyo Bay being provided by one of us (KK). According to his comparison, the morphologies of *E. calliops* that made it distinguishable from *E. kitoui* were the greater numbers of posterior teeth, higher ratios of tail segment length and eye length to BL, and different shapes of the eye pigment cup, which is darker and larger in *E. calliops* in relation to the eye size. As for the morphometric characters, however, it is likely that these depend on the specimen size due to allometric growth in chaetognaths. Indeed, *Parasagitta friderici* (Ritter-Zahony, 1911) is known to exhibit allometric growth (Daponte et al. 2004). The present nine specimens of *E. kitoui* also showed allometric growth. For example, the ratios of tail segment length (TSL) to BL in the two small specimens (4.0–5.8 mm BL, TSL/BL=27.5–27.6%) were markedly higher than those in the larger ones (8.3–18.1 mm BL, TSL/BL=23.3–25.4%). McLelland (1981) presented the individual data for metric characters measured on 13 *E. calliops* specimens of 8.4–21.5 mm BL and 10 *E. kitoui* specimens of 4.7–25.4 mm BL. We reanalyzed the interspecific differences using his data and the present data by omitting young individuals smaller than 10 mm BL to reduce variations due to allometric growth. The number of data used was 12 for each species. Out of the 12 sets of data on *E. kitoui*, six are from Tokyo Bay (McLelland 1981) and six are from Tosa Bay (present study), but no characters were significantly different between the two localities (Table 1). The results revealed that the ratios of the tail segment and the eye lengths (Fig. 2D) to the BL, and the numbers of hooks and posterior teeth on the head were all significantly different between *E. kitoui* and *E. calliops* \(p<0.05\), U-test. Among these characters, the range of the eye to body length ratio was disjunct between the species (0.79–0.96% in *E. kitoui* and 1.21–1.83% in *E. calliops*) and the difference was highly significant \(p<0.001\), while those of the other characters examined overlapped, indicating that eye size is the most critical morphological character separating the two species.

McLelland (1989) recognized that *E. calliops* differs from *E. kitoui* also in the position of the posterior end of the transverse musculature, which extends usually to the level of the posterior edge of the ventral ganglion in *E. kitoui* but beyond the ventral ganglion by 1/4 the length of the ganglion in *E. calliops*. In the present study, however, the position of the posterior end of the transverse musculature was observed to vary greatly according to specimen size. For example, the musculature extended apparently beyond the ganglion in the specimen of 18.1 mm BL, as in *E. calliops*, while it reached only the mid length of the ganglion in young specimens of 4.0 and 5.8 mm BL (Fig. 3). This indicates that the position of the
Fig. 2. Microphotographs of *Eukrohnia kitoui* from Tosa Bay. A: head, dorsal view; B: positions of anterior end of lateral fin (X) and anterior margin of ventral ganglion (Y); C: distal part of hook; D: dorsal view of eyes (upper side is anterior side). The eye length shown in D was measured as the maximum length of the major axis.

Table 1. Metric morphologies of *Eukrohnia kitoui* and *E. calliops* larger than 10 mm in body length based on McLelland’s (1989) and the present data. The mean values are presented with the ranges in parentheses. The significance probabilities for differences were calculated using *U*-test.

|                           | *E. kitoui* | Significance probability between two bays | *E. calliops* | Significance probability between two species |
|---------------------------|-------------|------------------------------------------|---------------|---------------------------------------------|
|                           | Tokyo Bay¹  | Tosa Bay²                                |               |                                             |
| Body length (BL) in mm    | 14.9 (10.4–25.4) | 15.5 (12.2–18.1) | 1.000 | 14.9 (10.4–21.5) | .347 |
| Ratio of tail segment to BL (%) | 23.5 (22.2–25.4) | 23.6 (22.3–25.4) | 1.000 | 25.7 (21.7–31.0) | .017* |
| Ratio of eye length to BL (%) | 0.89 (0.79–0.96) | 0.83 (0.74–0.90) | .065 | 1.54 (1.21–1.83) | .000** |
| No. of hooks³             | 11.3 (10–13)  | 10.5 (9–12)  | .310 | 12.2 (11.5–13) | .003** |
| No. of posterior teeth³   | 12.3 (7–16.5) | 9.0 (8–10)   | .177 | 14.5 (9–21) | .028* |

¹McLelland (1989; table 4).
²Present study.
³When the numbers of left and right hooks/teeth were different, the mean value was used.
*significant at *p*<0.05, **highly significant at *p*<0.01.
posterior end of the transverse musculature relative to the ventral ganglion is not a character allowing the two species to be distinguished.

According to the traditional morphological taxonomy of chaetognaths, the differences noted above are enough to distinguish *E. calliops* from *E. kitoui* at the species level. In fact, eyes have been used as an important diagnostic character for chaetognaths not only in adult specimens (e.g., Alvariño 1967) but also in immature ones (Nagasawa & Marumo 1976). However, Miyamoto et al. (2012) recently revealed that the deep-sea congeneric chaetognaths *Eukrohnia hamata* (Möbius, 1875) and *E. bathypelagica* Alvariño, 1962 genetically formed a single lineage in which they were intermixed. As for the present two species, it would also be interesting to study their genetic relationships if further specimens are collected for genetic studies.

Temperature and salinity profiles at 0.5 m intervals from the surface to the bottom were measured simultaneously with the sampling using a CTD logger (Compact-CTD, Alec Electronic Co. Ltd., Japan). The temperature decreased with depth from 23.1°C at the surface to 9.1°C at the bottom and the salinity ranged between 34.37 and 34.59 with high values around 34.5 or higher in the mid layer (120–220 m deep). The ranges of temperature and salinity in the 200–356 m sampling layer, from which *E. kitoui* was collected, were 9.0–15.7°C and 34.48–34.59, respectively. These values are almost the same as the conditions at which *E. kitoui* was collected in Tokyo Bay (10–15°C, 34.42–34.57, respectively; Kuroda 1981).

Both the closely allied species *E. calliops* from the Gulf of Mexico and *E. kitoui* from the Pacific coasts of Japan have been found restrictedly in or near submarine canyons, although records are still few. McLelland (1989) stated that a large number of *E. calliops* individuals were collected when the net accidentally dragged bottom near a submarine canyon and suggested that *E. calliops* is a hypo-planktonic species. From 2009 to 2010, one of us (HU) has conducted vertical hauls of the opening/closing net monthly from 200 m depth at the shelf margin and four times from 400 m depth in the slope water in the central part of Tosa Bay, and three times from >350 m depth at the present sampling point (one for the present study). However, *E. kitoui* was found only in the single sample described in the present study. A long absence of records since the original description, very rare occurrence in Tosa Bay, and characteristic collection sites suggest that *E. kitoui* is a rare species restricted to waters near or in coastal underwater canyons as suggested by McLelland (1989) for *E. calliops*.

**Acknowledgments**

We thank Mr. Zenji Imoto, the captain of the research boat *Neptune* of Usa Marine Biological Institute, Kochi University, and students of HU’s laboratory for their help in sampling.

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