Home range of the Japanese fluvial sculpin, *Cottus pollux*, in relation to nocturnal activity patterns

Takaharu Natsumeda

*Center for Ecological Research, Kyoto University, Shimo-sakamoto 4-I-23, Otsu 520-01, Japan*  
(e-mail: natsume@ecology.kyoto-u.ac.jp)

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**Synopsis**

Patterns of space use related to the activity of individual Japanese fluvial sculpins, *Cottus pollux*, were examined during the non-breeding season, in the upper reaches of the Inabe River, central Japan. Sculpins appeared more frequently at night than in daytime. Among 31 recaptured sculpins, 30 (96.8%) showed nocturnal activity patterns, there being no fish which exhibited an entirely diurnal activity pattern. Of 21 sculpins captured both in daytime and at night, the most common pattern of space use (n = 14, 66.7%) was that in which the nocturnal home range entirely encompassed the diurnal range. Overall, nocturnal home ranges were significantly larger than diurnal ranges. Active sculpins were rarely found on sand-associated substrata in daytime, but were seen more frequently on such substrata at night.

**Introduction**

Fish species are generally categorized into three groups according to their activity patterns: those which forage primarily in daytime (diurnal), those which forage principally at night (nocturnal), and those which forage mainly at dawn and dusk (crepuscular) (Emery 1973, Helfman 1986). All groups usually use feeding and resting sites, respectively, during their active and inactive periods (Gladfelter 1979), with some fishes exhibiting remarkable diel movements between these sites (Hobson 1965, Burke 1995). Evaluation of the patterns of space use by fishes related to activity is the first step in understanding their social structure.

Several authors have shown that activity patterns of fishes may change with ontogenetic development (Magnan & Fitzgerald 1984, Brandt 1986). In the case of creek chub, *Semotilus atromaculatus*, juveniles are essentially diurnal, whereas adults are principally nocturnal (Magnan & Fitzgerald 1984). However, most of these studies have been confined to the population level, because the majority of them were based on brief observations of unspecified individuals.

Katano (1987), who examined activity patterns of individual freshwater dark chub, *Zacco temminckii*, in a natural environment, showed that dark chub were mostly active in daytime, but that activity patterns varied markedly among individuals even during this time. To understand the social structure of fishes in detail, their activity patterns should be examined not at the population level, but at the individual level.

The Japanese fluvial sculpin, *Cottus pollux*, is endemic to the mountain streams of Honshu, Shikoku and Kyushu (Goto 1989). The species feeds predominantly on aquatic insects and small crustaceans (Mizuno & Gose 1972, Miyazaki et al. 1978), and grows mainly during summer and autumn (Natsum-
meda et al. 1997). Stable population densities from May to November (Nagoshi & Murakami 1980) suggest residential tendencies in the species during the non-breeding season. Diet changes in stomach fullness in summer¹ implies nocturnal activity in that season, although to date there have been few comprehensive studies on space use by sculpins related to activity patterns. Since the species has been shown to be a bottom-dweller (Goto 1989), space use by the sculpins within their home ranges might reflect their use of microhabitat features, such as substrate types.

This study aimed to examine diet changes in home range and substrata use in individual C. pollex during the non-breeding season, by capture-mark-and-recapture techniques.

**Study area and methods**

**Study area**

The study was conducted in the upper reaches of the Inabe River, Mie Prefecture, central Japan (35°10′N, 136°31′E). The study area was approximately 40 m long, and 5.5–9.5 m wide (306.8 m² in total area). Environmental characteristics and fish fauna around the study site have been described by Shimizu & Mori (1985). Japanese fluvial sculpin is one of the dominant species in the study area (Natsumeda et al. 1997).

**Capture-mark-and-recapture procedure**

Capture-mark-and-recapture censuses were conducted from June to December 1991, during the non-breeding season, being carried out in the evening (from 21:00 to 24:00 h), at midnight (from 0:00 to 4:00 h) and in daytime (from 16:00 to 17:00 h) for 5–7 days per month. One census required ca. 30 min.

Sculpins were located with a glass-based viewing box while the investigator moved an upstream. Each sculpin found was captured with a hand net and anesthetized in ca. 0.01% ethylene-glycol-monophenyl-ether solution. All fish exceeding 50 mm in standard length (SL, range = 53.0–104.5 mm) were marked individually by the removal of the 1st and 2nd dorsal fin spines and eye following the method of Goto (1985). SL was measured to the nearest 0.5 mm. Sex was determined according to the presence or absence of a genital papilla (present in males only) (Mizuno & Gose 1972). Thereafter, the fish were kept in a small tank until they had recovered from anesthetization (ca. 20–30 min), and were then released individually at their point of capture.

Before the census, the study area was mapped and plots selected at 1 m intervals along and across its course (297 lattice plots). The dominant substratum (occupying > 50% of bottom surface area) was recorded within a radius of 20 cm of each plot, substratum classification (seven categories) being based on a modified Wentworth particle scale: (1) boulder (> 25 cm), (2) rubble (6–25 cm), (3) gravel (3–6 cm), (4) granule (0.2–3 cm). (5) sand-rubble, (6) sand-gravel and (7) sand (1–2 mm) & silt (< 1 mm).

Before capture, the location of each fish found was recorded on the map with its status: (1) ‘active’ = entire body exposed, or (2) ‘hidden’ = body partially or entirely hidden. Classification of the substratum around each sculpin was determined in the same way as at lattice plots.

**Estimation of population size and appearance rate**

The population size and the variance of each sex in the study area was estimated by the capture-mark-and-recapture method using the following formula (Manly & Parr 1968, Manly 1971), which is applicable to a small sample size: