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Foraging and seasonal changes in food composition of *Onychodactylus fischeri* (BOULENGER, 1886) (Caudata: Hynobiidae)

Nahrungssuche und saisonale Änderungen der Nahrungszusammensetzung bei *Onychodactylus fischeri* (BOULENGER, 1886) (Caudata: Hynobiidae)

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KURZFASSUNG

Im Primorye-Gebiet des östlichsten Rußland wurden Nahrungssuche und Nahrungszusammensetzung bei *Onychodactylus fischeri* (BOULENGER, 1886) untersucht. Die Hauptkomponenten larvaler Nahrung sind an unterschiedlichen Orten des östlichen Rußland ähnlich. Bei Adulten sind jahrszeitlich bedingte Unterschiede in der Nahrungszusammensetzung deutlich ausgeprägt. Der Anteil wasserlebender Futtertiere an der Nahrung adulter Salamander ist unmittelbar vor und nach der Überwinterung hoch (Oktober - 58,5 % der Futtertier-Zahl; April-Mai - 81,6 %); der geringste Hydrobiontenanteil ist im Sommer (Juni-Juli - 12,0 %) und im Frühherbst (August-September - 0 %) festzustellen. In der Natur meiden kleine *O. fischeri*-Larven die Gegenwart größerer, was möglicherweise Kannibalismus verhindert. Aspekte des Freßverhaltens werden diskutiert.

ABSTRACT

Foraging and food composition were studied in *Onychodactylus fischeri* (BOULENGER, 1886) in the Primorye region, Far East Russia. Main larval prey components are similar in different localities of the Russian Far East. There are clear seasonal differences in adult food composition. The portion of hydrobionts in adult diet is high just after overwintering (April-May - 81.6 % of prey number) as well as just before overwintering (October - 58.5 %), and low in summer (June-July - 12.0 %) and early autumn (August-September - 0 %). In nature, small larvae of *O. fischeri* avoided to encounter big ones. This may prevent cannibalism. Some aspects of feeding behaviour are discussed.

KEYWORDS

Onychodactylus fischeri; feeding, foraging, prey, activity, ecology, behaviour; Far East Russia

INTRODUCTION

Several data are available on the feeding of larvae of different developmental stages, juveniles and adults of the hynobiid salamander *Onychodactylus fischeri* (BOULENGER, 1886), which inhabits the Pacific coastal mountain regions of Far East Russia, China and Korea (EMELIANOV 1940, 1947; KOROTKOV 1977; KUZMIN 1990). Analyses of stomach contents indicated almost entirely terrestrial feeding in this species, which is unusual in rheophilous Caudata of the Old World fauna (KUZMIN 1992). On the other hand, some authors reported *O. fischeri* to be primarily an aquatic forager (ZHIVOTCHENKO & al. 1977; LAPTEV & al. 1985). However, the latter authors did not provide any quantitative data. The present paper is dedicated to the study of the hitherto poorly known aspects of feeding and foraging of *O. fischeri* at some stages of the salamander's life cycle.

MATERIAL AND METHODS

Larvae and adults were obtained from upstreams of a tributary of the river Mineralnaya, Olga district, Primorye region of Far East Russia, between April and Oc-

tober 1991. The habitat is described elsewhere (SOLKIN 1993). Developmental stages of larvae were determined according to REGEL & EPSTEIN (1977).

Stomach contents were analysed in 76 specimens of various developmental stages.

For determination of seasonal dynamics of diet composition and to avoid killing we used the salamanders' faeces. Adult salamanders were caught and kept in clear aquaria, without food. Water was changed every day, faeces were removed, their components were determined. Stomach dissections indicated the prey to be composed mainly of hard-integumented invertebrates (KOROTKOV 1977; KUZMIN 1990; this paper). Thus, underestimation of completely digestible objects by faeces analysis is negligible. In total 113 faecal pellets (number of specimens see table 3) were examined.

Besides that, visual observations in larvae and adults were conducted in the natural environment at day and twilight times. Five cases of foraging in larvae and twelve in adult salamanders (10 at night, 2 at daytime) were observed.

RESULTS

Data on the size of the salamanders are presented in table 1. The youngest larvae found (stage 1/2) foraged mainly on larval Ephemeroptera, and, to a smaller extent, on Gammaridae and other arthropods (table 2). The diets of subsequent premetamorphic stages differed but slightly. Food of recently metamorphosed specimens was more diverse (table 2). It consisted almost exclusively of terrestrial invertebrates. Among hydrobionts only a few larval Chironomidae were consumed. Proportion of hydrobionts (Gammaridae and Plecoptera) clearly increased in subadults and decreased in adults. Stomachs were found empty in 31.9% of the juveniles (n=22), 20.0% of the subadults (n=5), 81.8% (n=12) of the adult males, and 14.3% (n=14) of the adult females. No food was found in males in reproductive state (pronounced hindleg skin folds), but food was found in females ready for oviposition. Analysis of the faecal pellets (table 3) revealed marked seasonal differences concerning the composition of aquatic prey. In spring 18.4 % of the prey spectrum consisted of terrestrial forms, whereas at the end of summer / beginning of autumn 100 % of the diet was formed by terrestrial prey.

Among 12 cases where adults were observed to forage in their natural environment, 11 occurred on land, just near the edge of the water (four times Diplopoda, twice Aranei, twice larval Lepidoptera, twice Carabidae: *Nebria* sp., once Lumbricidae), but only one in the water (10 cm deep - larval Plecoptera). When foraging on land the salamanders behaved as sit-and-wait predators. Distance of at-

Table 1: Developmental stage and size of 77 *Onychodactylus fischeri* specimens under study.

Tab. 1: Entwicklungsstadium und Größe der 77 untersuchten Exemplare von *Onychodactylus fischeri*.

Developmental stage	n	Snout-vent length (mm)	Tail length (mm)
1 (larva)	3	19.7 ± 0.33	16.3 ± 2.90
2 (larva)	9	25.6 ± 0.34	18.3 ± 0.50
3 (larva)	3	28.0 ± 0.58	19.3 ± 0.88
4 (larva)	8	36.6 ± 0.68	30.0 ± 0.92
5 (larva)	1	41.0	36.0
6 (juvenile)	22	41.6 ± 0.51	36.6 ± 0.60
(subadult)	5	49.6 ± 2.40	46.2 ± 2.90
(adult male)	12	71.7 ± 1.70	86.9 ± 2.30
(adult female)	14	76.1 ± 1.70	79.2 ± 2.00

Table 2: Food composition in *Onychodactylus fischeri* at different developmental stages in September 1991, according to stomach dissections (percentages based on prey number).

Tab. 2: Der prozentuelle Anteil der Stückzahlen einzelner Futtertiere an der Nahrung verschiedener Entwicklungsstadien von *Onychodactylus fischeri* im September 1991 aufgrund von Mageninhaltsanalysen.

Prey taxon	Developmental stage of prey	Developmental stage of *Onychodactylus fischeri*				
		1/2 (n=12)	3/4 (n=11)	juvenile (n=22)	subadult (n=5)	adult (n=26)
Lumbricidae		-	-	10.5	-	-
Gammaridae		13.3	35.3	-	5.9	-
Acarina		-	-	5.3	-	-
Aranei		-	-	21.1	35.3	33.3
Diplopoda		-	-	-	-	25.9
Collembola		-	-	5.3	-	-
Ephemeroptera	larvae	71.1	5.9	-	-	-
Plecoptera	larvae	8.9	47.1	-	23.5	3.7
Plecoptera	imagines	-	-	5.3	-	-
Trichoptera	larvae	-	5.9	-	-	-
Cicadodea	imagines	-	-	-	-	3.7
Lepidoptera	larvae	-	-	21.1	-	7.4
Lepidoptera	imagines	-	-	-	5.9	-
Staphylinidae	imagines	-	-	-	-	7.4
Elateridae	larvae	-	-	5.3	-	-
Hymenoptera	imagines	-	-	-	-	3.7
terrestrial Diptera		-	-	15.8	5.9	11.1
Chironomidae	larvae	6.7	5.9	5.3	-	-
Diptera	imagines	-	-	5.3	23.5	-
Asiliidae	imagines	-	-	-	-	3.7

tack was always 1 - 2 cm. The salamander under water actively searched for food.

In all five cases of foraging where larvae were involved, the animals attacked terrestrial insects fallen into the water (caterpillars of *Papilio maackii* MEN., *Smerinthus tatarinovi* BREM. & GREY, imaginal *Hipparchus papilionaria* L.).

Only prey of suited size was consumed. However, attacks were also directed against too large and therefore unsuited invertebrates of their own size.

Six hours of observation revealed that larvae of similar body size coexisted in small streampools without displaying mutual avoidance. However, if the coexisting larvae differed from one another by more than one developmental stage (e. g. 1 and 4), the smaller specimens avoided the larger ones. When a big larva approached a small one (63 observations), the latter moved away as soon as their mutual distance became shorter than about three times the length of the smaller larva.

DISCUSSION

Comparison of larval diet composition in *O. fischeri* from the Mineralnaya river basin (this paper) and other localities of Far East Russia (EMELIANOV 1940, 1947; KUZMIN 1990) reveals identical main prey components: Gammaridae, larval Ephemeroptera and Plecoptera. Single records of terrestrial invertebrates in large salamander larvae (KUZMIN 1990) may be related to the use of terrestrial habitats by larvae of the final metamorphic stages, and to predation of invertebrates fallen into the water. The latter is confirmed by observations made on larvae in the field. Small larvae avoid to associate with large larvae. This was observed also under laboratory conditions (KUZMIN 1991, 1992) and may be a mechanism preventing larval cannibalism.

Like in the majority of the Caudata, recently metamorphosed *O. fischeri* prey almost exclusively on land. Transition to

Table 3: Food composition in adult *Onychodactylus fischeri* in different months of the year 1991. Results of faecal pellet examination (percentages based on prey number).

Tab. 3: Der prozentuelle Anteil der Stückzahlen einzelner Futtertiere in den Exkrementen adulter *Onychodactylus fischeri* in verschiedenen Monaten des Jahres 1991.

Prey taxon	April-May (n = 35)	June-July (n = 25)	August-September (n = 28)	October (n = 25)
Gammaridae	17.2	12.0	-	58.5
Ephemeroptera, larvae	27.3	-	-	-
Plecoptera, larvae	37.1	-	-	-
AQUATIC PREY, totally	81.6	12.0	-	58.5
Arachnoidea	7.1	19.8	11.8	-
Diplopoda	11.3	44.5	50.2	27.3
Lepidoptera	-	8.6	11.3	-
Coleoptera	-	15.1	26.7	14.2
TERRESTRIAL PREY, totally	18.4	88.0	100.0	41.5

periodic aquatic foraging occurs at subadult stages.

The proportion of hydrobionts in the diet of adult salamanders changes by season. In spring, just after overwintering and before reproduction (end of April - beginning of May), adult salamanders forage mainly in the streams. They hold higher numbers of active invertebrates at this time than terrestrial habitats during and just after the snow melting. In summer and beginning of autumn, adults forage almost exclusively on land. This coincides with an increased abundance of active terrestrial invertebrates. In October, before overwintering, adult *O. fischeri* were found in the streams again, indicating that foraging occurs in the aquatic environment at that time. Thus, informations on almost exclusive preying on either terrestrial (KOROTKOV 1977; KUZMIN 1990, 1992) or aquatic (ZHIVOTCHENKO & al. 1977; LAPTEV & al. 1985) invertebrates by *O. fischeri* simply reflects the time when the salamanders were sampled. Seasonal shifts of adult foraging sites in relation to hydrobiont availability are also known from other rheophilous Caudata (e. g. *Mertensiella caucasica* - EKVTIMISHVILI 1948). However, in other rheophilous caudata these shifts are not as much pronounced as in *O. fischeri*, and the amount of aquatic organisms in their diets retains a relatively high level throughout the active period.

As indicated by KUZMIN (1990) cessation of food intake was absent in *O. fischeri* during its reproductive period. Food was found in both reproductive males and females. In this respect, the absence of food in reproductive males as reported in the present work is difficult to interpret.

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