Japanese Journal of Ichthyology
Vol. 29, No. 3 1982

魚類学雑誌
29巻3号 1982年

An Analysis of the Diets of Four Spatially Overlapping Damselfishes of the Genus *Chromis*

Gordon W. Tribble and Hitoshi Nishikawa

(Received July 3, 1981)

Abstract The diets of four planktivorous damselfishes of the genus *Chromis* from Miyake-jima, Izu Islands, were compared. Copepods, principally of the genera *Pleuromamma*, *Euchaeta*, *Scolecithrix*, and *Eucalanus*, plus larvaceans, were the predominant dietary items. There were no significant differences between damselfish species regarding the type of copepods consumed at the generic level. Also, it does not appear that the damelfishes selected different sized food items. However, one species, *Chromis flavomaculata*, appears distinct from its three congeners, *C. albomaculata*, *C. analis*, and *C. chrysura*, in having a diet containing significantly more copepods and fewer larvaceans.

There has been much work recently on the feeding and dietary interactions of damselfishes. Nearly all of these investigations have focused on territorial and benthic-feeding members of this family (e.g. Lobel, 1980). In comparison, little work has been done on planktivorous damselfishes. Although several workers have reported planktonic material in the stomachs of numerous damselfish species (Hiatt and Strasberg, 1960; Hobson, 1965; Randall, 1967; Swerdloff, 1970a, b), detailed studies of their diets are lacking. The work of Swerdloff (1970a) on two Hawaiian *Chromis* is a notable exception to this.

In the present study, the diets of the damelfishes *Chromis albomaculata* Kamohara, *C. analis* (Cuvier), *C. chrysura* (Bliss), and *C. flavomaculata* Kamohara were studied at Igaya Bay, Miyake-jima, Japan. Adults of these four congeners are roughly similar in size, ranging from 110 to 135 mm SL, and are often encountered feeding in the same area. The goal of this study was to determine the degree of dietary similarity in these four species.

Methods and materials

All specimens were collected by spearing at Igaya Bay, Miyake-jima (34°04′N, 139°30′E), Izu Islands. Between Octover 9 and December 11, 1979, six cohorts of fishes were collected. To reduce sampling variation and facilitate statistical analysis, each cohort contained one member of each of the four damselfish species being compared. Fish comprising a group were collected within an hour of each other in the late afternoon. For additional examination, another 29 specimens (2 *C. albomaculata*, 1 *C. analis*, 10 *C. chrysura*, 16 *C. flavomaculata*) were also collected during the study. All fishes were collected at a single site 20～28 m deep, near a submarine lava cliff in the bay.

Immediately after returning to shore, 3～5 ml of 90% formalin were injected into the body cavity of each specimen to retard digestion of the stomach contents. Within three hours, the specimens were dissected and the stomachs removed. Contents were examined under a dissecting microscope. To reduce sampling variation, one author (GWT) visually estimated the relative composition of hard and soft plankton. Hard plankton consisted of crustaceans and polychaete larvae; soft plankton was comprised of larvaceans and chaetognaths. The length of intact prey items was then measured to within 0.1 mm using a stage micrometer. Later, one of us (HN) performed a generic-level systematic analysis of the stomach-content material.

Because some of the assumptions inplicit in parametric analysis were not necessarily met, data were analysed with non-parametric tests. Two statistical tests were used. Friedman's rank test for two-way classification (Tate and Clelland, 1957) uses rank values to test for differences between sets of data with two variables; it is analogous to the parametric two-way

analysis of variance (see Sokal and Rolf, 1969). The Kruskall-Wallis H-test (Sokal and Rolf, 1969) was applied to sets of data where only a single variable was being considered; it is analogous to a one-way analysis of variance (see Sokal and Rolf, 1969). In examining the data, three questions were formulated to investigate the dietary relationships between the four congeners. These questions were:

Are there differences between species in the relative amount of hard and soft plankton consumed?

Do the congeners differ in the size of prey items ingested?

Are there small-scale phylogenetic differences in the damelfish prey?

Results

Systematic analysis of prey items. All dietary items were of planktonic origin with the exception of a small fish vertebra found in the stomach of a 135 mm SL male *C. analis*. Recognizable stomach contents consisted of copepods, shrimp and polychaete larvae, the shrimp *Lucifer*, larvaceans (Appendicularia), chaetognaths (Sagittoidea) and fish eggs (Table 1). Aside from soft plankton, which were usually too digested to be reliably identified, only copepods were sufficiently abundant to warrant an interspecific comparison. They comprised 81.9% (n=2184) of all identifiable food items, and 96.3% (n=1853) of the identifiable hard plankton.

Eleven different genera of copepods were recognized. Table 2 shows the average numbers of individuals of each prey genera found in the stomachs of the four *Chromis* species. The most common prey genera were *Euchaeta*, *Pleuromamma*, *Scolecithrix*, and *Eucalanus*.

Table 1. Total number of identified food items from the stomachs of 5 *C. albomaculata*, 5 *C. analis*, 7 *C. chrysura* and 8 *C. flavomaculata*.

Food class		Number of items	Percent of total
Hard plankton	Copepods	1788	81.9
	Shrimp larvae	45	2.1
	Polychaete larvae	11	0.5
	Lucifer	4	0.2
	Other crustaceans	13	0.6
Soft plankton	Larvaceans	285	13.0
	Chaetognaths	35	1.6
	Fish eggs	2	0.1
	Fish remains	1	0.1

In testing for dietary differences between the damselfishes, one of the six groups of fishes was omitted from analysis due to a lack of identifiable food items in one specimen. Copepod composition from the guts of specimens in the remaining five cohorts were compared using Friedman's rank test, the variables considered being fish species and prey genera. The results indicate that while the different genera of copepods were significantly different in overall occurence ($X^2=23.7$, df=8, $P<0.005$), there was no difference between the four fish species with respect to the type of copepods consumed

Table 2. Average number of identified individuals of different copepod genera from the stomachs of each of the four *Chromis* species. The standard error is given in parenthesis.

Copepod genus	*Chromis albomaculata* n=5	*Chromis analis* n=5	*Chromis chrysura* n=7	*Chromis flavomaculata* n=8
Pleuromamma	7.2 (2.3)	8.8 (3.8)	11.1 (5.7)	11.5 (4.5)
Euchaeta	6.0 (2.9)	17.4 (2.1)	22.0 (13.8)	31.4 (17.7)
Scolecithrix	3.8 (2.5)	26.4 (7.6)	12.3 (4.5)	15.9 (3.0)
Calanus	3.8 (1.1)	2.0 (1.2)	5.7 (3.7)	5.4 (3.5)
Eucalanus	9.0 (6.4)	8.8 (3.4)	12.9 (7.2)	5.1 (2.9)
Candacia	3.0 (1.0)	2.6 (1.3)	2.7 (1.2)	3.5 (1.9)
Corycaeus	1.4 (1.0)	1.2 (1.2)	2.0 (1.2)	2.6 (1.4)
Rhincalanus	1.8 (1.8)	1.4 (1.4)	1.9 (2.4)	2.5 (1.3)
Aetideus	0.4 (0.4)	—	0.6 (0.6)	—
Oncaea	—	—	3.0 (2.6)	17.6 (12.1)
Undinula	—	0.4 (0.4)	—	—

($X^2=2.9$, df=3).

Analysis of the size of prey items. We also measured the length of intact food items to determine if the four *Chromis* species ingested different sized food items. Hard and soft plankton were considered separately due to the large phylogenetic and morphological differences between them (Table 3). For both hard and soft plankton, we used Friedman's rank test to compare the mean lengths of food items from the six cohorts of fishes. The variables analyzed were fish species (within cohorts) and replication dates (between cohorts). No significant size differences were found between species for either hard ($X^2=6.1$, df=3) or soft ($X^2=6.75$, df=3) plankton. However, significant differences were found in the size of prey items from different days, independent of species, for both hard ($X^2=12.9$, df=5, $P<0.025$) and soft ($X^2=12.6$, df=5, $P<0.05$) plankton. Thus, although the average size of ingested plankton varied between days, there appears to be no significant difference between species in the size of prey items selected.

Relative composition of hard and soft plankton. Lastly, we investigated the relative amount of hard and soft plankton in the congener's diets. Friedman's rank test was applied to the values of percent soft plankton composition in the stomachs of fishes in the six cohorts. The variables analyzed were fish species (within cohorts) and replication date (between cohorts). Values for hard plankton were not directely analyzed because hard and soft plankton were the only dietary components; thus, consumption patterns of hard plankton should mirror those

Table 3. Number and average lengths (in mm) of hard and soft plankton in the stomachs of the four *Chromis* species.

Fish species	No. of fish	Hard plankton		Soft plankton	
		No. of items	Average length	No. of items	Average length
Chromis albomaculata	6	473	2.1	133	5.6
Chromis analis	6	594	2.2	171	5.5
Chromis chrysura	6	594	1.9	114	5.8
Chromis flavomaculata	6	766	1.9	56	5.5

Table 4. Relative percent composition of hard and soft plankton in all *Chromis* specimens examined.

Fish species	No. of fish	Percent hard plankton		Percent soft plankton	
		Median value	Mean and standard error	Median value	Mean and standard error
Chromis albomaculata	8	60.0	62.5 (26.6)	40.0	37.5 (26.6)
Chromis analis	7	65.0	60.7 (7.0)	35.0	39.3 (7.0)
Chromis chrysura	16	75.0	73.1 (3.3)	25.0	26.9 (3.3)
Chromis flavomaculata	22	95.0	91.9 (1.3)	5.0	8.1 (1.3)

Table 5. Results of Kruskal-Wallis H-tests testing for differences in the relative composition of hard and soft plankton between the four *Chromis* species with all specimens considered.

Species analyzed	Total number of samples	H value	df	P
All four species	53	30.0	3	<0.005
All but *C. albomaculata*	45	28.6	2	<0.005
All but *C. analis*	46	23.5	2	<0.005
All but *C. chrysura*	37	19.0	2	<0.005
All but *C. flavomaculata*	31	3.2	2	NS

found for soft plankton. A marginally significant difference between days was found ($X^2=10.8$, df=8, $0.1>P>0.05$) in the relative amount of soft plankton in the diets of the fishes, independent of species. Also, there was a highly significant difference ($X^2=11.5$, df=3, $P<0.01$) between species in the relative amount of soft plankton consumed.

To investigate this interspecific difference further, we considered the percent of soft plankton material in all specimens collected (8 *C. albomaculata,* 7 *C. analis,* 16 *C. chrysura,* 22 *C. flavomaculata*) (Table 4) and tested for differences between species with a Kruskal-Wallis H-test. Again, a significant difference ($P<0.005$) between species was found (Table 5). The values for the median percent composition of hard and soft plankton in Table 4 suggest that *C. flavomaculata* is responsible for this difference. To confirm this, four additional H-tests were run in which only three of the four species were analyzed at one time (Table 5). Significant differences between species remained in all cases except where *C. flavomaculata* was omitted from analysis. These data strongly suggest that *C. albomaculata, C. analis,* and *C. chrysura* consume similar relative amounts of hard and soft plankton, while *C. flavomaculata* ingests significantly less soft plankton than its congeners.

Discussion

Overall, there appears to be little dietary difference between the four damselfish species. Copepods were the major food of all species, and no differences were found in the type of copepods, at the generic level, consumed by the congeners. Also, there were no apparent differences between species in the size of either hard or soft plankton ingested.

Chromis flavomaculata appears to be distinct from its three congeners in having a diet more restricted to copepods. This may be because in the water column at the study area, *C. flavomaculata* foraged 1～3 m above the other three species (Bell, pers. comm.). Thus, it cannot be clearly ascertained if the dietary differences between *C. flavomaculata* and its congeners are due to the active selection of different prey items, or if the upper part of the water column simply contains fewer soft plankton than the water a few meters deeper.

Swerdloff (1970a), in his thorough study of two Hawaiian *Chromis,* found no dietary differences between species with respect to either major taxa or copepod genera. He also noted that the diets of the fishes did not vary with depth; fish collected from 10, 20, and 30 m had essentially similar diets.

The data also suggests, to a limited degree, that plankton composition differed between sampling days. The mean sizes of both hard and soft plankton prey items differed significantly between days, and there was also a slight difference in the relative amount of hard and soft plankton consumed. Presumably, this reflects temporal changes in the overall plankton community, and underscores the importance of collecting comparitive samples together to minimize sample variation.

Acknowledgments

We are very grateful to Mr. Jack T. Moyer and Mr. Yutaka Yogo for helping us to corodinate our efforts. Great thanks are also due to Dr. Fumihiro Koga for systematic advice, and to Dr. Stephen Ralston and Dr. Alfred Ebeling for statistical assistance, Dr. Hiroshi Tsukahara, Mr. Jack Moyer, and Miss Lori Bell kindly reviewed and improved the manuscript. This is contribution number 42, Tatsuo Tanaka Memorial Biological Station, and a contribution of the Fisheries Laboratory, Kyushu University.

Literature cited

Hiatt, R. W. and D. W. Strasberg. 1960. Ecological relationships of the fish fauna on coral reefs of the Marshall Islands. Ecol. Monogr., 30(1): 65～127, fig. 1.

Hobson, E. S. 1965. Diurnal nocturnal activity of some inshore fishes in the Gulf of California. Copeia, 1965(3): 291～302, fig. 1.

Lobel, P. S. 1980. Herbivory by damselfishes and their role in coral reef community ecology. Bull. Mar. Sci., 30: 273～289, fig. 1.

Randall, J. E. 1967. Food habits of reef fishes of the West Indies. Stud. Trop. Oceanog., 5: 665～847.

Sokal, R. R. and F. J. Rolf. 1969. Biometry. W. H. Freeman, San Francisco, 776 pp.

Swerdloff, S. N. 1970a. The comparative biology of two Hawaiian species of the damselfish genus *Chromis* (Pomacentridae). Ph. D. thesis, University of Hawaii, 192 pp, 45 figs.

Swerdloff, S. N. 1970b. Behavioral observations on Eniwetok damselfishes (Pomacentridae: *Chromis*) with special reference to the spawning of *Chromis caeruleus*. Copeia, 1970(2): 371～374, figs. 1～2.

Tate, M. W. and R. C. Clelland. 1957. Non-parametric and shortcut statistics in the social, biological, and medical sciences. Interstate Printers and Publishers, Danville, Illinois, 171 pp.

(GWT: Tatsuo Tanaka Memorial Biological Station, Ako, Miyake-jima, Tokyo 100-12, Japan; present address: 4074 Puu Eleele Pl., Honolulu, Hawaii 96816, U.S.A.; HN: Faculty of Agriculture, Kyushu University, Hakozaki-6, Higashi-ku, Fukuoka 812, Japan)

生息域が一部重なるスズメダイ科 *Chromis* 属4種の餌料

Gordon W. Tribble・西川　仁

伊豆諸島の三宅島において，*Chromis flavomaculata*, *C. albomaculata*, *C. analis*, および *C. chrysura* の4種について胃内容物からプランクトン餌料を比較した．

餌料はカイアシ類とオタマボヤ類がそのほとんどで，*C. flavomaculata* は他の3種に較べカイアシ類が多く，オタマボヤ類が少なかった．

また，カイアシ類では主に *Pleuromamma*, *Euchaeta*, *Scolecithrix* および *Eucalanus* の4属のものが多く，これらの胃内容物組成については *Chromis* 属4種の間に有意な差はなかった．

(Tribble: 100-12 東京都三宅島阿古　田中達男記念生物実験所；現住所：米国ハワイ；西川：812 福岡市東区箱崎　九州大学農学部水産学第二講座)