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Initial Survey: Stomach Contents of Potential Fish Predators of Juvenile Chinook Salmon (*Oncorhynchus tshawytscha*) in the Nechako River, B.C.

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INITIAL SURVEY:

STOMACH CONTENTS OF POTENTIAL FISH PREDATORS OF JUVENILE CHINOOK SALMON (Oncorhynchus tshawytscha) IN THE NECHAKO RIVER, B.C.

by

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Stomachs of 40 rainbow trout (Oncorhynchus mykiss), 24 northern squawfish (Ptychocheilus oregonensis), 20 mountain whitefish (Prosopium williamsoni) and 2 bull trout (Salvelinus confluences) captured in the Nechako river during autumn were analyzed for gut content. Each of the fish species consumed a different set of prey organisms. Rainbow trout consumed the widest range of organisms, primarily drift insects. Mountain whitefish consumed small benthic insects, primarily larval chironomidae. Northern squawfish consumed primarily small fish; rodent remains were identified in two of the stomachs. A juvenile chinook salmon was obtained from the stomach of one of the bull trout.

RÉSUMÉ

Brown, T. G., B. Bravender, P. Dubeau, and R. Lauzier. 1992. Initial survey: Stomach contents of potential fish predators of juvenile chinook salmon (Oncorhynchus tshawytscha) in the Nechako River, B.C. Can. Manuscr. Rep. Fish. Aquat. Sci. 2141: 33 p.

Le contenu de l'estomac de 40 truites arc-en-ciel (Oncorhynchus mykiss), de 24 sauvagesses du Nord (Ptychocheilus oregonensis), de 20 ménominis des montagnes (Prosopium williamsoni) et de 2 ombles à tête plate (Salvelinus confluences) capturés dans la rivière Nechako à l'automne a été analysé. Chacune de ces espèces de poisson consommait une variété différente d'espèces de proie. La truite arc-en-ciel consommait la plus vaste gamme d'organismes, principalement des insectes flottant à la dérive. Le ménomini des montagnes préféraît les petits insectes benthiques, surtout des larves de chironomidés. La sauvagesse du Nord se nourrissait principalement de petits poissons; des restes de rongeurs ont été identifiés dans 2 des estomacs. Un saumon quinnat juvénile a été trouvé dans l'estomac de l'un des ombles à tête plate.

INTRODUCTION

This report summarizes the information collected during autumn of 1990 on the feeding habits of fish species which have been reported to be predators on juvenile chinook salmon (Oncorhynchus tshawytscha). The purpose of this study was to determine the kinds of food eaten by the potential predators and the number of juvenile chinook salmon they consumed. Subject to a court case now being heard, flow will decrease and temperature regimes within the Nechako River will be altered. This report provides an initial record of the autumn feeding habits of rainbow trout (Oncorhynchus mykiss), northern squawfish (Ptychocheilus oregonensis), mountain whitefish (Prosopium williamsoni), and bull trout (Salvelinus confluences) prior to those proposed changes. Results obtained will also assist in the planning of future studies on predator-prey relationships within the Nechako River.

METHODS

Eighty-eight fish were captured for gut analysis between September 8 and October 13, 1990. Capture was by either rod and reel or by beach-seine. Mountain whitefish smaller than 107 mm were preserved whole, while all fish larger than 107 mm had their stomachs removed. Rainbow trout and bull trout had their stomach contents removed by gastric lavage (Light et al. 1983) and were released after recovery.

Fifty-five kilometres of river were sampled by rod and reel to obtain 75 fish (Table 1). Sampling sites were located from Cheslatta Falls to the Fort Fraser Bridge. The majority of sampling, (92% of effort) was conducted above Diamond Island. All sites were numbered in kilometres starting at Cheslatta Falls, (Nechako River Project 1987). Fishing took place during the day and artificial lures were used.

Two beach-seines at each of 3 sites provided an additional catch of 13 mountain whitefish for gut analysis (Table 2). Beach-seining was conducted on September 11 and September 13, 1990 during the day at sites located between 9 km and 30 km below Cheslatta Falls. A beach-seine of approximately 50 ft was launched from a jet-boat and pulled to shore by hand. No attempt was made to estimate population size or accurately identify minor species. The sole purpose of these beach-seines was to obtain mountain whitefish for gut analysis.

Gastric lavage was used as a technique to obtain stomach samples from anaesthetized game fish without killing them. First, a tube attached to a syringe was inserted down the throat into the fish's stomach. Second, water was pumped from the syringe down the tube into the stomach, flushing out material held there. This procedure was repeated 4 times with all material flushed from the fish stomach being collected in a pan. Lastly, collected material was transferred to a labelled container and preserved with a 10% formaldehyde solution. Nine rainbow trout stomachs from fish which had been subjected to gastric lavage were retained to evaluate the effectiveness of the technique.

Mean daily water discharge and water temperature were measured by a continuously recording data logger located approximately 12 km below Cheslatta Falls (Unpublished data. Department of Fisheries and Oceans, Fisheries Operations, Vancouver). Water discharge during the period of capture remained relatively constant ranging from 33.2 cubic meters/sec on September 8, 1990 to 29.8 cubic meters/sec on October 13, 1990. Water temperature decreased gradually, from a maximum of 16.6°C on September 8, 1990 to a minimum of 9.1°C on October 13, 1990. On October 11, 1990 snow fell and reduced the mobility of the sampling crew; mean daily water temperature dropped below 10°C, and catch per unit effort declined to near zero. Sampling terminated on October 13, 1990.

Eighty-eight fish stomachs were analyzed by Applied Technical Services (ATS) and results were presented in a contract report (ATS 1991). A very detailed statement of the methods used during gut analysis was also given in ATS (1991). Special emphasis was placed on identifying any fish remains. However, identification was difficult, as often only a scale or fish bone was all that remained of prey fish found within the stomach contents.

RESULTS

1. CATCH / EFFORT BY ROD AND REEL

A total of 75 fish were taken on artificial lures using 171 person-hrs of effort (Table 1). Catch/effort was highly variable over the 55 km of river sampled, with the greatest catch/effort recorded at Cheslatta Falls (.69 fish/person-hr) and at Larson's (.60 fish/person-hr). Catch/effort for the upper 55 km of river was .44 fish / person-hr. Catch/effort was similar

for the two periods of sampling; 0.46 fish / person-hr in September 1990 and 0.41 fish / person-hr in October 1990 (Figure 1), although catch declined sharply during the last three days fished in October.

2. FISH SIZE DISTRIBUTION

The majority of fish caught by rod and reel were rainbow trout (40/75). These fish ranged in length from 170 mm to 368 mm (Figure 2), and mean length was 263 mm. The size of the captured fish was uniformly distributed throughout the size range (Figure 2). Only 10% of the rainbow trout were longer then the sports fishing limit of 350 cm.

Mountain whitefish accounted for 7 of the 75 fish caught by rod and reel. An additional 18 mountain whitefish were captured by beach-seine, of which 13 were retained for gut analysis (Salmonidae indicated in Table 2). The larger mountain whitefish (mean 299 mm, SE 12.4 mm) were captured by rod and reel, while the smaller whitefish (mean 156 mm, SE 16.9 mm) were captured in the beach-seine (Figure 3). Size distribution seems to indicate gregarious groupings, possibly age classes.

Northern squawfish accounted for 24 of the 75 fish caught by rod and reel, (Figure 4). These fish were the largest captured, averaging 321 mm in length and 385 gm in weight. It is possible that, as was noted for the whitefish, only the larger squawfish were caught by rod and reel, as the majority (79%) were over 300 mm in length.

Two bull trout, 1 white sucker (Catostomus commersoni), and 1 juvenile chinook salmon were also captured by rod and reel. The bull trout were obtained from deep pools located at 24 km and at 50 km below Cheslatta Falls. From the same locations two more bull trout were hooked but not landed. The single juvenile chinook salmon was obtained from the plunge pool of Cheslatta Falls.

3. GASTRIC LAVAGE

Considerable difficulties were encountered using gastric lavage as a means of obtaining stomach samples. Nine rainbow trout had both their pumped stomach contents and remaining stomach contents analyzed separately (Figure 5). Only 51% of the total stomach content by weight and 28% by number were evacuated using this technique and there was considerable

variation between individual fish. Fish size had no apparent influence on effectiveness of the technique as both small and large fish were pumped with varying success.

No apparent differences in taxonomic composition were found between the pumped organisms and the organisms remaining after pumping. Insects comprised 98% of the pumped organisms and 99% of the organisms remaining after pumping. Only one occurrence of fish remains was left following pumping (sculpin, 1360 mg), while two occurrences (cyprinidae, 200 mg and unidentified fish bones, 20 mg) were removed with pumping.

The technique of gastric lavage was modified slightly between the first six and last three rainbow trout sampled (Figure 5). Greater care was taken in positioning the fish and in ensuring that the throat was open. An improvement in percentage of organisms pumped from 16% to 94% resulted.

4. STOMACH CONTENTS

(A) Numerical Data

Within the 88 fish stomachs examined, a total of 6234 items were found of which 6118 were identifiable (Table 3). The greatest number of organisms were Insecta (90.8%) and Crustacea (6.4%). All other taxa combined represented 2.8% of the total number of identifiable organisms. Numerically fish accounted for only 0.5% of the diet. The most abundant food organisms were Chironomidae (52.2%) and Trichoptera (23.4%).

The mean number of items in the stomachs varied between species; 184 for mountain whitefish, 58 for rainbow trout, and 4 for northern squawfish. Mountain whitefish stomachs were dominated by Chironomidae (80.6%) and Trichoptera (13.7%). Rainbow trout stomachs contained a much wider range of organisms, the most numerous being Trichoptera (38.9%) and Chironomidae (6.7%). Trichoptera (55.7%) and Mollusca (11.4%) were the most abundant items in northern squawfish stomachs, however only 88 items were recovered from this fish species.

(B) Occurrence Data

Eighty-eight fish stomachs were examined of which 6 (northern squawfish) were empty. Within the 82 fish stomachs containing food items (Table 4) the most commonly occurring taxa were: Trichoptera (51.9%), Plecoptera (51.9%), Ephemeroptera (46.9%), Chironomidae (44.4%), Hemiptera (34.6%), and fish

remains (30.9%). Ninety-five percent of the stomachs examined contained insects.

All major food taxa were present in rainbow trout, (Table 4). The most commonly occurring food items were; Plecoptera (83%), Trichoptera (70%), Hemiptera (55%) and Ephemeroptera (55%). The frequent occurrence of non-food items such as small pieces of vegetative material were also noted in rainbow trout stomachs (22/40). The wide range of food items noted in rainbow trout may indicate a more opportunistic feeding behaviour (Fausch 1991).

Mountain whitefish had a high occurrence of only a few major taxa (Table 4). The most commonly occurring taxa were; Chironomidae (90%), Trichoptera (90%), and Ephemeroptera (65%). Mountain whitefish, due in part to specialized mouth and jaw shape, may exhibit a feeding behaviour which limits them to a narrower range of organisms.

No single prey taxa occurred with any regularity within the northern squawfish stomachs except insects. Fish remains were present in 7 of the 24 northern squawfish stomachs and 6 were empty.

(C) Weight Data

The weights of each prey taxa are summarized by fish species in Table 5. The prey items comprising the majority of the identifiable gut contents by weight, for the 88 fish examined were insects (55%) and fish remains (34%). The mean weight of gut contents by species was: rainbow trout, 2.0 gm (n = 40, sd = 2.4); northern squawfish, 1.9 gm (n = 24, sd = 2.8); mountain whitefish, 0.5 gm (n = 20, sd = 0.9); and 2.8 gm/fish for the two bull trout captured.

The majority of rainbow trout gut contents by weight (Figure 6) consisted of insects (65.7%) and fish remains (16.7%). Although only 23 Odonata were identified in the stomachs of rainbow trout they comprised 36.4% of the total Insecta weight due to their relatively large size. Trichoptera (21.5%), Plecoptera (22.4%), and Anisoptera (6.5%) were also dominant prey orders of insects found in rainbow trout stomachs. The mean weight of prey items found in rainbow trout stomachs was 36 mg (n = 2252, SE = 4).

The major food items identified within northern squawfish stomachs by weight (Figure 7) were; fish remains (53.7%), insects (22.9%), and rodent remains (18.1%). As with rainbow trout, although only 4 Odonata were identified in northern squawfish stomachs they represented 85.3% of Insecta weight due to their large size. Two rodents were identified in

the stomachs of two different northern squawfish. The mean weight of prey items found within northern squawfish was 550 mg (n = 84, SE = 190).

For mountain whitefish, gut content by weight was dominated by insects, (80.3%; Figure 8). Dominant Insecta orders included; Trichoptera (69.3%), Plecoptera (9.5%), and Diptera (8.6%). The mean weight of prey items within mountain whitefish stomachs was 2.7 mg (n = 3663, SE = 0.14).

(D) Stage of Insecta

Each of the fish species utilized different life stages of insects (Figure 9), although larval insects were by far the dominant stage consumed. Rainbow trout consumed more adult, sub-adult, nymph and pupa stages then did either mountain whitefish or northern squawfish. Larval forms accounted for over 90% of the weight of insects consumed by mountain whitefish. Differences in the consumption of insect life stages may indicate differences in location of food acquisition as non-larval stages would tend to reside on the water surface or within the water column, while larval stages would tend to reside on or within the substrate.

(E) Presence of Fish

Approximately 25% of the fish stomachs examined, yielded an occurrence of fish remains (Table 6). The number of occurrences of fish in the stomachs was similar for rainbow trout (35%) and northern squawfish (29%). Mountain whitefish stomachs had the lowest, (10%) occurrence of fish remains. Although only two bull trout were captured, both of these had consumed fish.

The commonest type of fish identified within the stomachs of the 88 fish examined were sculpins (7/16; Table 7). Six cyprinids, of which two were juvenile northern squawfish and 4 were unidentifiable (possibly either red-side shiner or dace species), were noted in the stomachs of rainbow trout. The single occurrence of a juvenile chinook was noted within the stomach contents of a bull trout. It is likely that both occurrences of fish remains found within mountain whitefish stomachs were fish eggs, however only one occurrence was confirmed.

(F) Specific Taxa Found in Stomachs

a) Mollusca: The Gastropoda, Lymnea sp. was the most commonly occurring Mollusca in the fish stomachs examined. This taxa represented 98% by weight and 94% by number of the Mollusca identified.

b) Diptera: Order and stage of Diptera prey differed between fish species. This difference is apparent when comparing the life stage of diptera consumed by rainbow trout and mountain whitefish (Table 8). Although chironomids were consumed by both species, mountain whitefish ate mainly larval chironomids (96% of Diptera by number) while rainbow trout ate pupal and adult chironomids (60% of Diptera by number).

c) Trichoptera: Larval stages of three families (Hydropsychidae, Brachycentridae, and Hydroptilidae) accounted for over 97% of the Trichoptera identified. Hydropsychidae were the most abundant Trichoptera family represented in all of the fish species examined.

d) Plecoptera: The Perlidae nymph stage accounted for 77% of rainbow trout and 70% of mountain whitefish, identifiable stone-fly prey.

e) Odonata: Adult dragonflies accounted for 26 of the 28 Odonata identified. The adult dragonflies averaged over 0.9 grams in weight, and although few in number, represented a high percentage of the total weight of prey items (20%). The most commonly occurring family was Aesnidae which accounted for 9 of 24 dragonflies that were identifiable to family.

f) Anisoptera: The 4 Anisoptera identified averaged 0.8 grams in weight and similar to Odonata, although few in number they represented a high percentage of the total weight (2%).

g) Coleoptera: Rainbow trout consumed 38 of the 44 coleoptera. All were adults, of which the most common families identified were Gyrinidae (16/30) and Carabidae (8/30).

h) Ephemeroptera: Baetidae represented 41/46 of the mayflies present in mountain whitefish and 97/127 present in rainbow trout. All Baetidae consumed by mountain whitefish were nymphs while 33%, (32/97) consumed by rainbow trout were sub-adults. Heptageniidae nymphs (30/127; rainbow trout and 2/46; mountain whitefish) and Leptophlebiidae nymphs (3/46; mountain whitefish) were also consumed. Although only one sucker stomach was examined in this survey, it contained 13 Ephemeroptera of which 8 were Ephemerellidae.

i) Homoptera: All identifiable Homoptera were adult Aphidae. Rainbow trout consumed 33 of 34 Homoptera.

j) Hymenoptera: All Hymenoptera identified were adults; Braconidae (11/38), Ichneumonidae (13/38), and Formicidae (8/38). Rainbow trout consumed 51 of 52 Hymenoptera.

DISCUSSION

Although the stomach contents of only 88 fish were analyzed in this study, our findings were consistent with those of other studies. The type and number of prey organisms consumed by the various fish species did differ and the results may be an indication of differences in feeding behaviour.

Consumption of fish eggs by mountain whitefish was noted in this study. Mountain whitefish have been reported to consume eggs and alevins of trout and salmon (Carl et al. 1967; McHugh 1940). Mountain whitefish captured in October in the Snake River were reported to have consumed whitefish eggs (Pontius and Parker 1973). Mountain whitefish eggs were the most abundant item in the diet of mountain whitefish captured in October and November in Yellowstone River (Laakso 1950).

In this study mountain whitefish consumed primarily small benthic organisms, dominated numerically by chironomidae larva. A high occurrence of chironomids in whitefish taken from B.C. lakes and rivers has been reported (McHugh 1940). High percent abundance of Chironomidae (69.9%) and Trichoptera (25.2%) were noted in mountain whitefish stomachs (Pontius and Parker 1973). Chironomids were present in all 75 of the mountain whitefish examined from the Teton River and accounted for 51.5% of the food items present (Overton et al. 1978). Ellison (1980), reported that the main items food items of mountain whitefish were Ephemeroptera (61.1%) and Diptera (26%).

We noted mountain whitefish stomachs contained mostly immature aquatic insects. A similar finding by Ellison (1980), suggested a bottom feeding habit. Morphology of the whitefish's mouth and occurrence of sand and gravel in stomachs are also an indication of bottom feeding (Pontius and Parker 1973). Thompson and Davies (1976) suggested the sub-terminal mouth is an adaption for feeding at or near the bottom. Underwater observations indicate mountain whitefish remained within approximately 2 to 10 cm of the bottom while feeding (Thompson and Davies 1976).

Northern squawfish stomachs were often empty or near empty. When organism were present they consisted of large items such as sculpins or rodents. Northern Squawfish have been characterized as "opportunistic predators" on fish and invertebrates, consuming the most abundant prey items (Brown and Moyle 1981). Juvenile chinook salmon were 48.5% of the diet (percent weight) of northern squawfish in the John Day Reservoir (Poe et al. 1986). Thompson and Tufts (1967) found 54% of 656 northern squawfish were empty and approximately 20% had consumed sockeye fingerlings. In rivers, under natural conditions it is doubtful if northern squawfish are major predators on salmonids

(Buchanan et al. 1981). In Lake Washington, prickly sculpin (Cottus asper) was the major food item of northern squawfish (70%), while salmonids accounted for 30% of the food items (Eggers et al. 1978). Northern squawfish may feed more heavily and frequently than the high percentage of empty stomachs suggest due to their very rapid digestion rates (Brown and Moyle 1981).

In this study the rainbow trout appeared to be more opportunistic feeders, consuming the widest variety of prey, primarily drift organisms. Rainbow trout are considered "generalists" that "forage rather opportunistically" on a wide variety of food items (Fausch 1991). Rainbow trout have been reported to consume salmon fry (Ginetz and Larkin 1976; Fresh and Schroder 1987). In streams rainbow trout consumed mainly aquatic invertebrate drift (Fausch 1991).

Only two bull trout stomachs were analyzed, however both contained fish remains and very little else. Bull trout feed on fish and benthic organisms such as molluscans and larval insects (Carl et al. 1967). Schutz and Northcote (1972), have reported that the closely related Dolly Varden (Salvelinus malma) is more successful than trout in capturing benthic prey at low light intensities. Roos (1959), examined over 5,000 Dolly Varden stomachs captured during summer and determined 52.8% were empty, and the main food items were insects 73.2% and sockeye fry 9.0%. Examination of 171 Dolly Varden captured in Lake Wenatchee, Washington, revealed that approximately 42% of the Dolly Varden stomachs contained sockeye fingerlings (Thompson and Tufts 1967).

Rainbow trout, larger squawfish and bull trout can consume chinook juveniles, however evidence of chinook predation was limited to one occurrence within a bull trout stomach. Numerous occurrences of other small fish (sculpins, juvenile northern squawfish, juvenile mountain whitefish and unidentified cyprinidae) indicated a wide range of prey organisms were available to the piscivorous fish within the Nechako river. These other small fish may compete for space and food with juvenile chinook and their relative numbers may be of ecological importance in regulating chinook production.

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Table 1. Catch by rod and reel at locations on the Nechako River. Location is distance in kilometres below Cheslatta Falls and effort is represented by person hours of fishing.

Site	Location (km)	Effort (hrs)	Species Caught by Rod and Reel					
			Bull	Rbt	Squaw	White	Chin	Sucker
Cheslatta Falls	0-1	29		13	2	4	1	
Bert's	5-9	12		1	1			
River Ranch	12-17	5						
Greer Creek	24-36	41	1	7	7			
Larson's	40-50	47	1	13	11	2		1
Diamond Island	60-68	23		5	3	1		
F.Fraser Bridge	122-126	14		1				
Total		171	2	40	24	7	1	1

Table 2. Catch by beach-seine at locations on the Nechako River. Location is distance in kilometres below Cheslatta Falls. Number of fish retained for stomach analysis is represented in brackets.

Site	Location (km)	Sets	Beach-seine Catch			
			Cyprinidae	Cottidae	Catostomidae	Salmonidae
Bert's	7	2	47	1	1	4 (4)
River Ranch	16	2	77	1	0	13 (8)
Greer Creek	25-32	2	227	4	0	1 (1)
Total		6	351	6	1	18 (13)

Table 3. Total number of each prey taxa identified for each fish species.

	BULL	RBT	SQUAW	WHITE	CHINOOK	SUCKER	TOTAL
FISH							
CHINOOK	1	0	0	0	0	0	1
CYPRINIDAE	0	8	0	0	0	0	8
SCULPIN	0	3	4	0	0	0	7
SQUAW	0	2	0	0	0	0	2
UNIDENTIFIED	1	4	2	1	0	0	8
EGGS	0	4	0	1	0	0	5
WHITE	0	1	1	0	0	0	2
FISH TOTAL	2	22	7	2	0	0	33
ARACHNIDA	0	8	0	0	0	0	8
CRUSTACEA	0	396	0	0	0	0	396
HYDRACARINA	0	3	0	25	0	1	29
NEMATODA	0	0	0	0	0	1	1
MOLLUSCA	0	19	10	22	0	0	51
INSECTA							
DIPTERA							
CACACEIDAE	0	1	0	0	0	0	1
CHIRONOMIDAE	1	155	1	2960	5	124	3246
CULICIDAE	0	6	0	0	0	0	6
DOLICHOPODIDAE	0	3	0	0	0	0	3
MUSCIDAE	0	12	0	0	0	0	12
SCIOMYZIDAE	0	7	0	0	0	0	7
SIMULIIDAE	0	62	0	16	0	0	78
SYRPHIDAE	0	1	0	0	0	0	1
TIPULIDAE	0	6	0	1	0	1	8
UNIDENTIFIED	0	109	1	1	1	1	113
DIPTERA TOTAL	1	362	2	2978	6	126	3475
ANISOPTERA	0	4	1	0	0	0	5
COLEOPTERA	0	38	3	3	0	0	44
EPHEMEROPTERA	0	142	1	53	1	13	210
HEMIPTERA	0	79	2	8	0	0	89
HOMOPTERA	0	33	0	1	0	0	34
HYMENOPTERA	0	51	0	1	0	0	52
LEPIDOPTERA	0	2	1	0	0	0	3
ODONATA	0	23	4	1	0	0	28
ORTHOPTERA	0	2	0	0	0	0	2
PLECOPTERA	0	133	0	14	0	10	157
SIPHONAPTERA	0	1	0	0	0	0	1
TRICHOPTERA	0	894	49	502	0	7	1452
UNIDENTIFIED	0	40	3	53	0	0	96
INSECTA TOTAL	1	1804	66	3614	7	156	5648
RODENT	0	0	2	0	0	0	2
FEATHER	0	2	1	0	0	0	3
PLANT	1	22	0	5	0	1	29
REMAINS	1	12	1	2	0	0	16
SAND	1	11	1	3	1	1	18
GRAND TOTAL	6	2299	88	3673	8	160	6234

Table 4. Total number of occurrences of prey items for each fish species.

	BULL (2)	RBT (40)	SQUAW (24)	WHITE (20)	CHINOOK (1)	SUCKER (1)	TOTAL (88)
FISH							
CHINOOK	1	0	0	0	0	0	1
CYPRINIDAE	0	2	0	0	0	0	2
SCULPIN	0	3	4	0	0	0	7
SQUAW	0	2	0	0	0	0	2
UNIDENTIFIED	1	4	2	1	0	0	8
EGGS	0	3	0	1	0	0	4
WHITE	0	1	1	0	0	0	2
FISH	2	14	7	2	0	0	25
ARACHNIDA	0	6	0	0	0	0	6
CRUSTACEA	0	4	0	0	0	0	4
HYDRACARINA	0	2	0	6	0	1	9
NEMATODA	0	0	0	0	0	1	1
MOLLUSCA	0	3	2	2	0	0	7
INSECTA							
DIPTERA							
CACACEIDAE	0	1	0	0	0	0	1
CHIRONOMIDAE	1	14	1	18	1	1	36
CULICIDAE	0	4	0	0	0	0	4
DOLICHOPODIDAE	0	3	0	0	0	0	3
MUSCIDAE	0	8	0	0	0	0	8
SCIOMYZIDAE	0	5	0	0	0	0	5
SIMULIIDAE	0	7	0	4	0	0	11
SYRPHIDAE	0	1	0	0	0	0	1
TIPULIDAE	0	4	0	1	0	1	6
UNIDENTIFIED	0	12	1	1	1	1	16
DIPTERA	1	22	2	18	1	1	45
ANISOPTERA	0	3	1	0	0	0	4
COLEOPTERA	0	12	3	1	0	0	16
EPHEMEROPTERA	0	22	1	13	1	1	38
HEMIPTERA	0	22	1	5	0	0	28
HOMOPTERA	0	10	0	1	0	0	11
HYMENOPTERA	0	17	0	1	0	0	18
LEPIDOPTERA	0	1	1	0	0	0	2
ODONATA	0	12	4	1	0	0	17
ORTHOPTERA	0	2	0	0	0	0	2
PLECOPTERA	0	33	0	8	0	1	42
SIPHONAPTERA	0	1	0	0	0	0	1
TRICHOPTERA	0	28	5	18	0	1	42
UNIDENTIFIED	0	7	3	3	0	1	14
INSECTA	1	39	15	20	1	1	77
RODENT	0	0	2	0	0	0	2
FEATHER	0	2	1	0	0	0	3
PLANT	1	22	0	5	0	1	29
REMAINS	1	12	1	2	0	0	16
SAND	1	9	1	3	1	1	16
EMPTY	0	0	6	0	0	0	6

Table 5. Total weight (mg) of each prey taxa for each fish species.

	BULL	RBT	SQUAW	WHITE	CHINOOK	SUCKER	TOTAL
FISH							
CHINOOK	5440	0	0	0	0	0	5440
CYPRINIDAE	0	1910	0	0	0	0	1910
SCULPIN	0	5551	18177	0	0	0	23728
SQUAW	0	608	0	0	0	0	608
UNIDENTIFIED	2	132	3896	1	0	0	4018
EGGS	0	302	0	228	0	0	530
WHITE	0	5000	2729	0	0	0	7729
FISH TOTAL	5542	13401	24802	228	0	0	43873
ARACHNIDA	0	39	0	0	0	0	39
CRUSTACEA	0	64	0	0	0	0	64
HYDRACARINA	0	3	0	4	0	0	7
NEMATODA	0	0	0	0	0	0	0
MOLLUSCA	0	1049	2102	12	0	0	3163
INSECTA							
DIPTERA							
CACACEIDAE	0	1	0	0	0	0	1
CHIRONOMIDAE	1	220	1	601	5	6	834
CULICIDAE	0	17	0	0	0	0	17
DOLICHOPODIDAE	0	106	0	0	0	0	106
MUSCIDAE	0	134	0	0	0	0	134
SCIOMYZIDAE	0	18	0	0	0	0	18
SIMULIIDAE	0	174	0	75	0	0	249
SYRPHIDAE	0	148	0	0	0	0	148
TIPULIDAE	0	12	0	1	0	3	16
UNIDENTIFIED	0	323	2	3	2	1	331
DIPTERA TOTAL	1	1153	3	680	7	10	1853
ANISOPTERA	0	3477	300	0	0	0	3777
COLEOPTERA	0	865	450	40	0	0	1355
EPHEMEROPTERA	0	588	26	393	5	19	1031
HEMIPTERA	0	1402	18	130	0	0	1550
HOMOPTERA	0	45	0	1	0	0	45
HYMENOPTERA	0	1757	0	40	0	0	1797
LEPIDOPTERA	0	503	20	0	0	0	523
ODONATA	0	19372	8951	164	0	0	28487
ORTHOPTERA	0	701	0	0	0	0	701
PLECOPTERA	0	11939	0	758	0	24	12721
SIPHONAPTERA	0	2	0	0	0	0	2
TRICHOPTERA	0	11435	795	5503	0	15	17748
UNIDENTIFIED	0	85	3	234	0	2	322
INSECTA TOTAL	1	53323	10566	7943	12	68	71912
RODENT	0	0	8375	0	0	0	8375
FEATHER	0	16	55	0	0	0	71
PLANT	30	589	0	107	0	31	757
REMAINS	0	11923	263	1127	0	0	13313
SAND	100	722	0	476	40	802	2140
GRAND TOTAL	5573	81129	46163	9897	52	901	143663

Table 6. Occurrence of fish in predatory fish stomachs.

Species	(N)	Occurrence of Fish in Gut		
		Number of Occurrences	Percentage	Avg Number When Present
Northern squawfish	24	7	29%	1.0
Rainbow trout	40	14	35%	1.2
Mountain whitefish	20	2	10%	1.0
Bull trout	2	2	100%	1.0
Sucker	1	0	0%	0
Chinook juvenile	1	0	0%	0
Total	88	25	28%	

Table 7. Species or taxa of fish identified in the stomachs of four of the fish species.

Species	Type of fish identified in stomach contents						
	Chinook	Whitefish	Squawfish	Sculpin	Cyprinid	Unknown	Eggs
N.Squawfish		1		4		2	
Rainbow		1	2	3	4	4	3
M.Whitefish						1	1
Bull trout	1					1	
Total	1	2	2	7	4	8	4

Table 8. Percentages of Diptera by type (taxa and stage) for numerical data, found in stomachs of mountain whitefish and rainbow trout.

Type	Mountain whitefish	Rainbow trout
Chironomid larva	96%	2%
Chironomidae pupa and adults	3.5%	60%
Simuliida pupa and adults	0.5%	23%
Other Diptera pupa and adults	0%	11%
Other Diptera larva	0%	4%

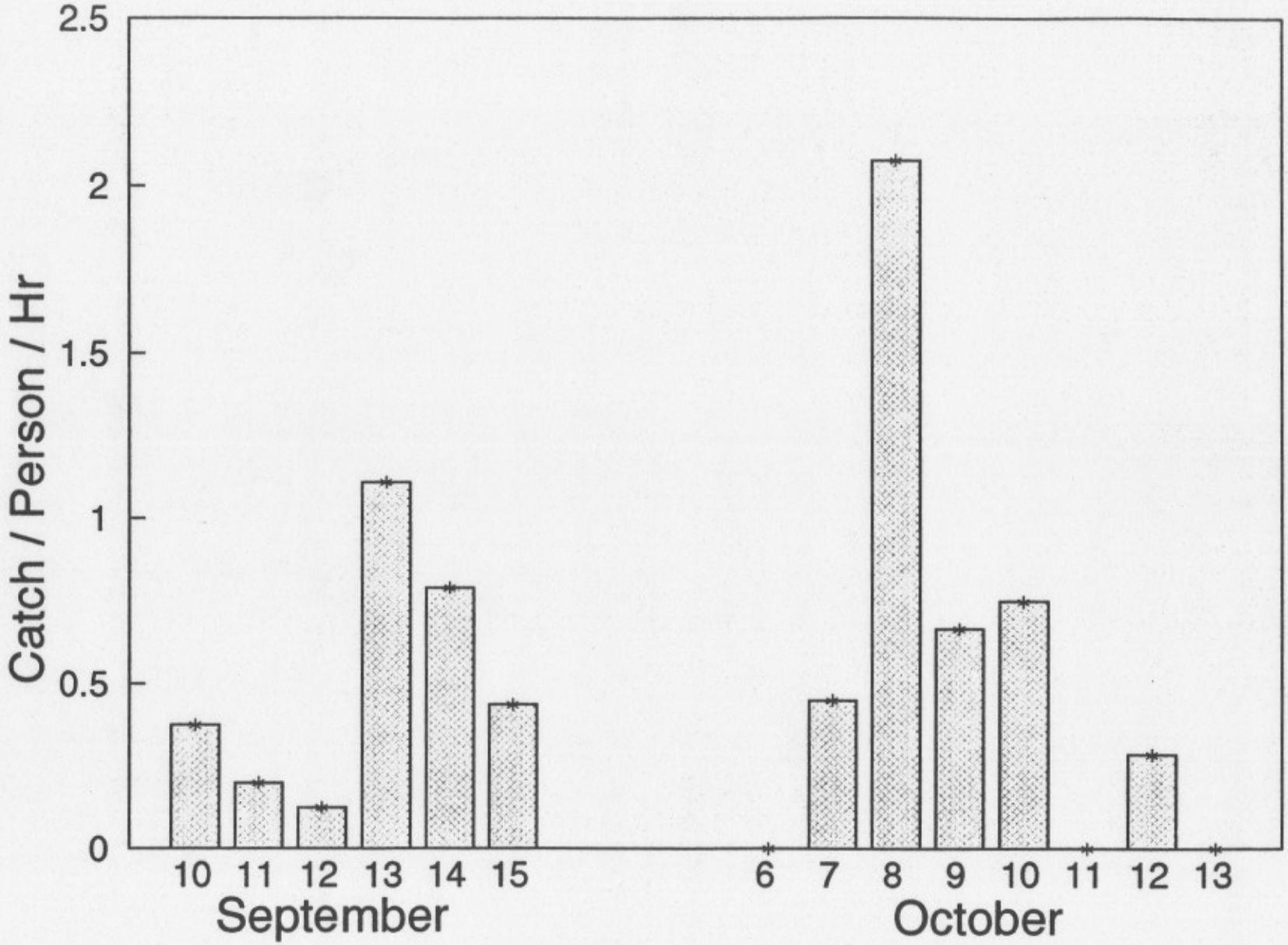


Figure 1. Catch of all fish species per fishing hour for each day of sampling. Fish were obtained by rod and reel using aritficial lures.

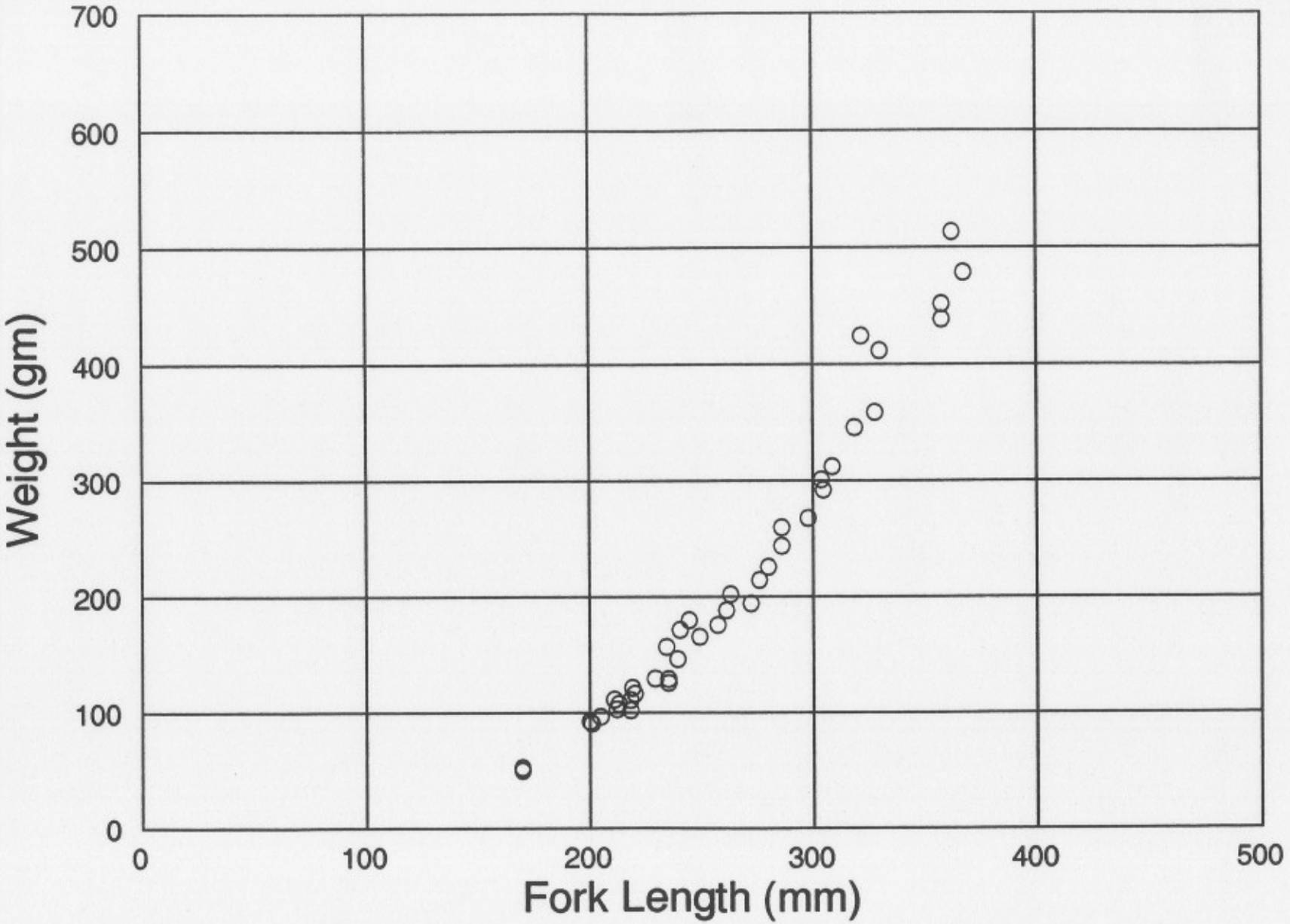


Figure 2. Length weight relationship of rainbow trout captured by rod and reel.

Fork length (mm)
0
100
200
300
400
500
600
Weight (gm)
0
100
200
300
400
500
600
700

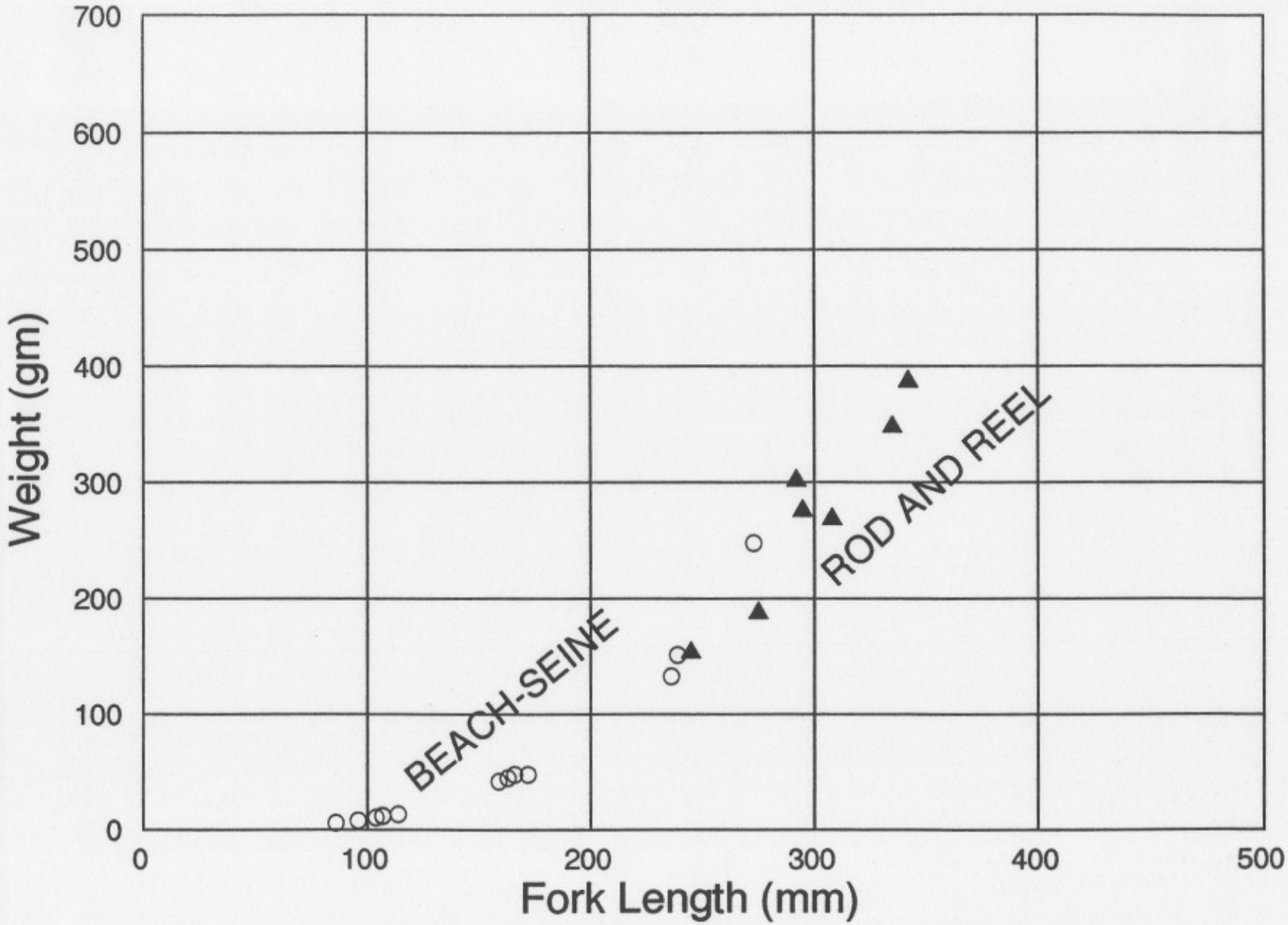


Figure 3. Length weight relationship of mountain whitefish captured by rod and reel and by beach-seine.

Fork length (mm)
Weight (g)
0
100
200
300
400
500
600
700
800
900
POD AND REEF
BEACH-SEINE

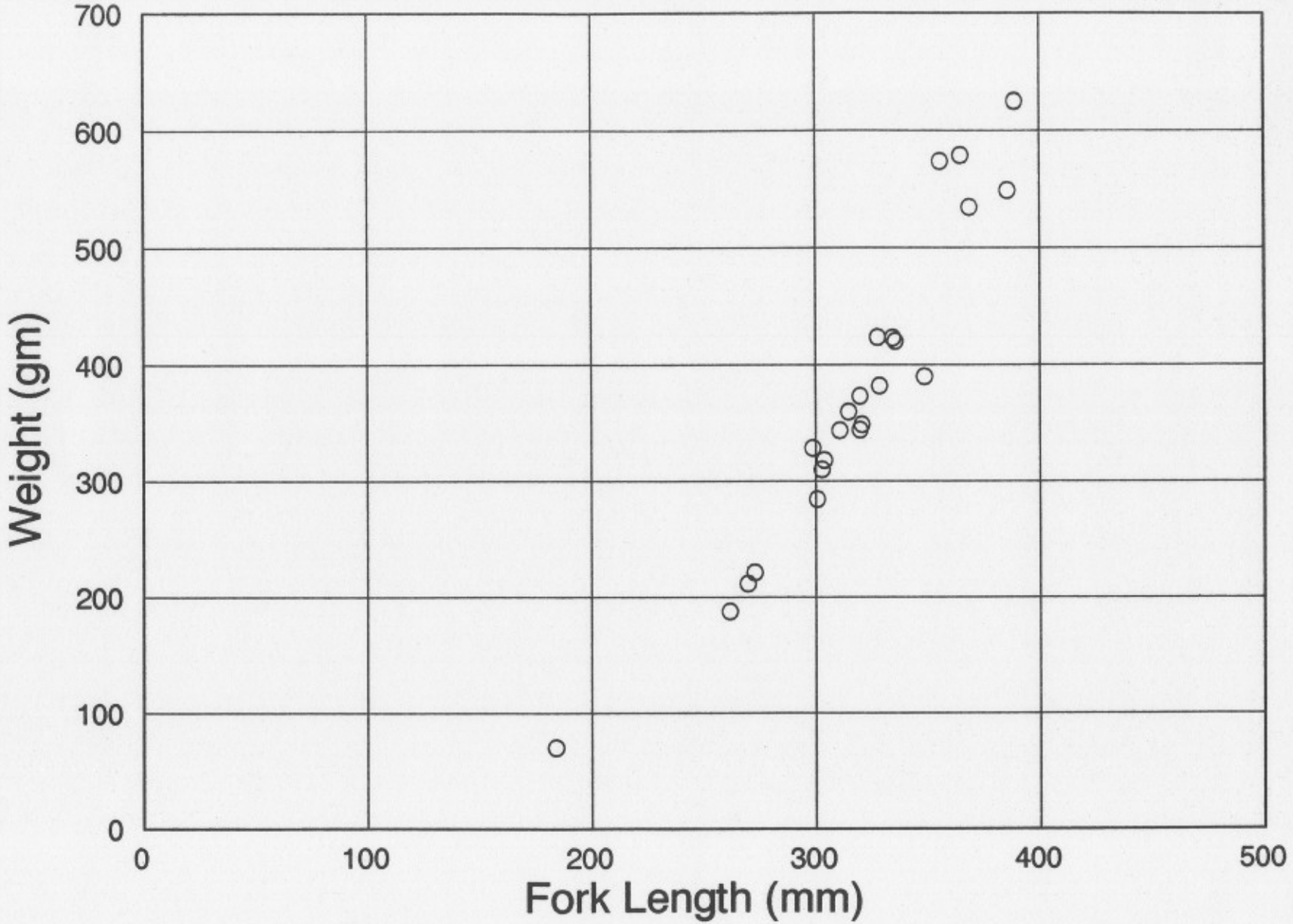


Figure 4. Length weight relationship of northern squawfish captured by rod and reel.

Fork length (mm)
0
100
200
300
400
500
Weight (g)
0
10
20
30
40
50
60
70

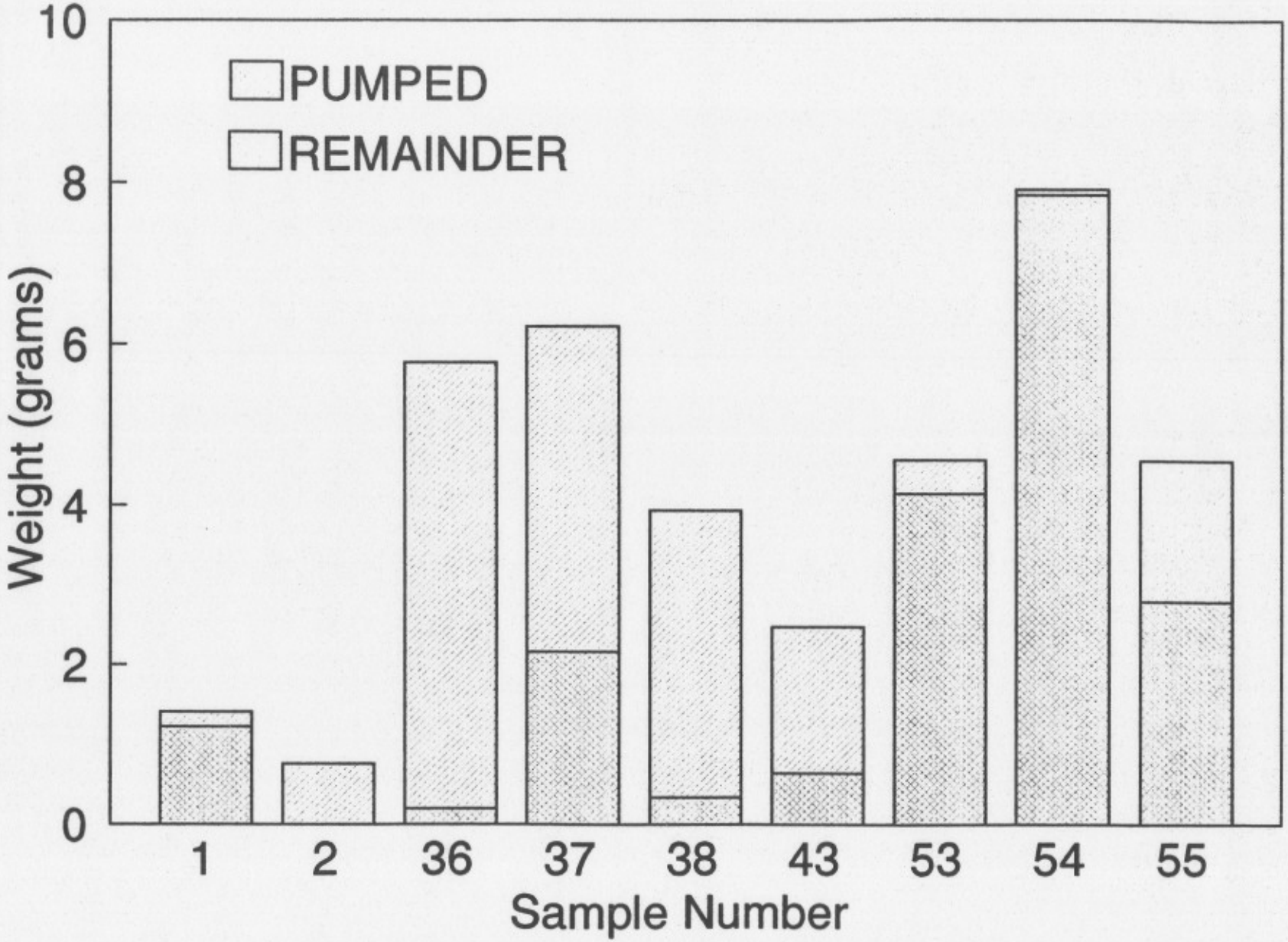


Figure 5. A comparison of weight of gut contents removed by gastric lavage (pumped) and weight of gut contents remaining within the stomach following gastric lavage (remainder) for nine rainbow trout caught by rod and reel.

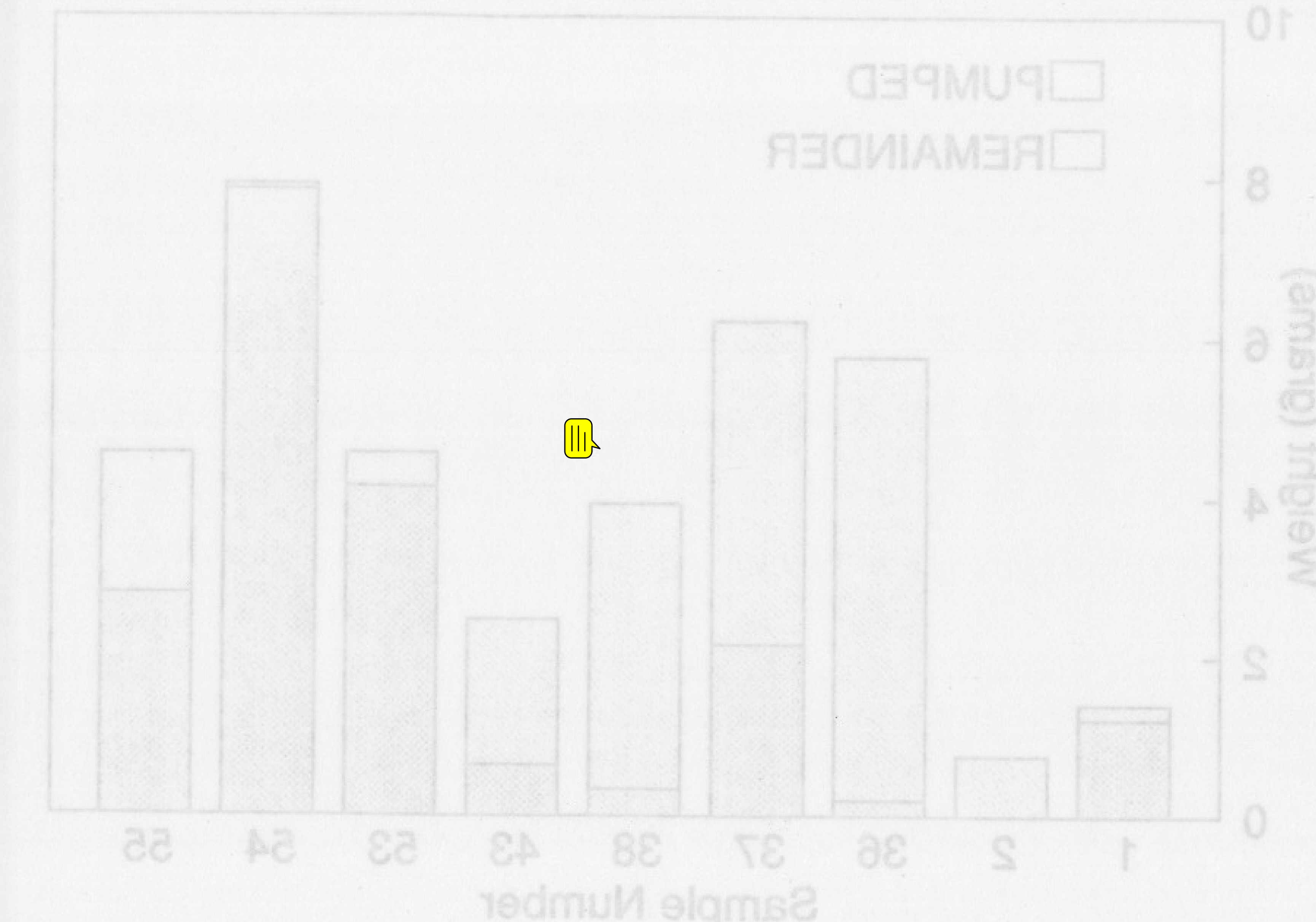


Figure 5. A comparison of weight of gut contents removed by gastric lavage (pumped) and weight of gut contents remaining within the stomach following gastric lavage (remainder) for nine rainbow trout caught by rod and reel.

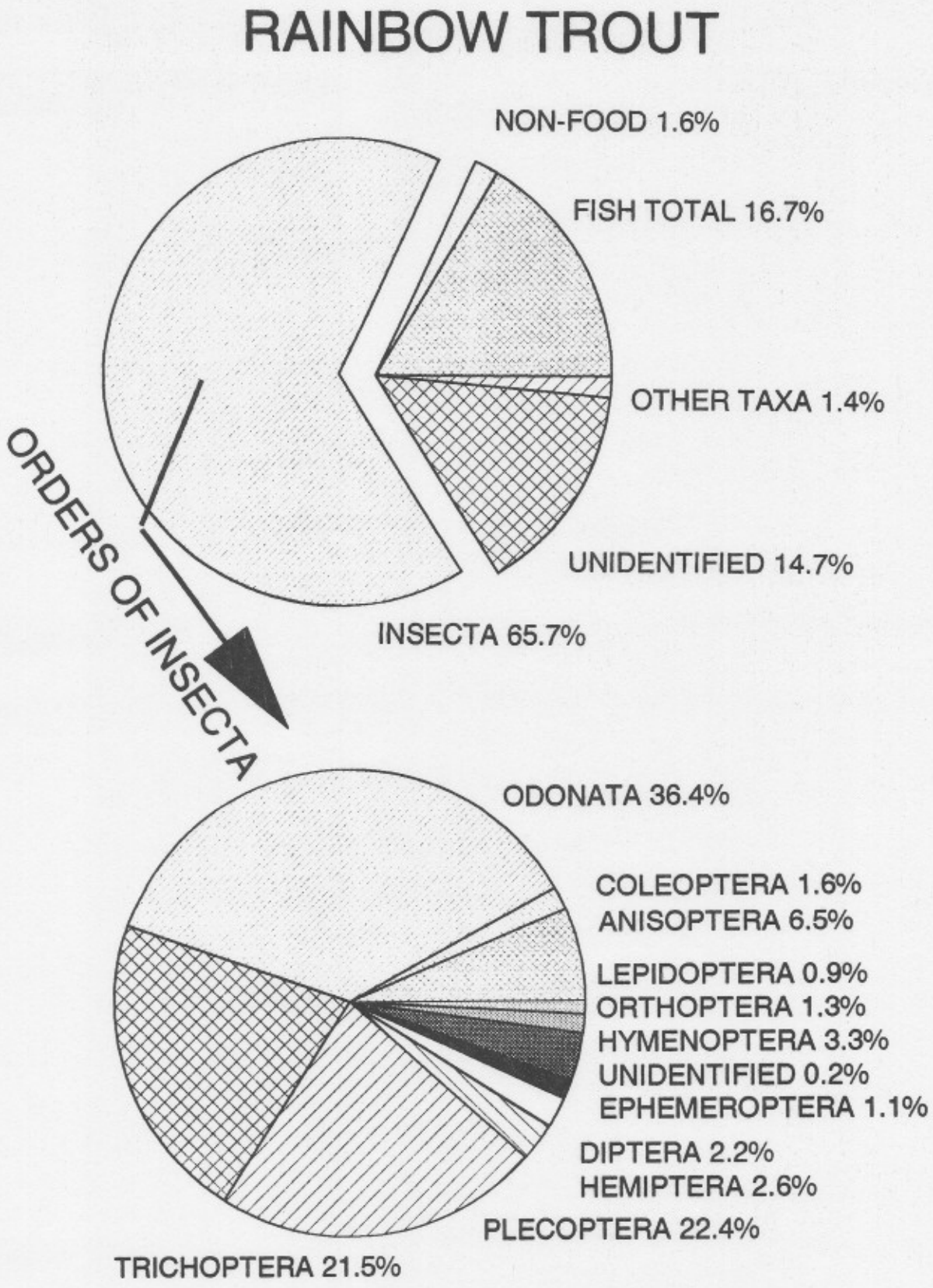
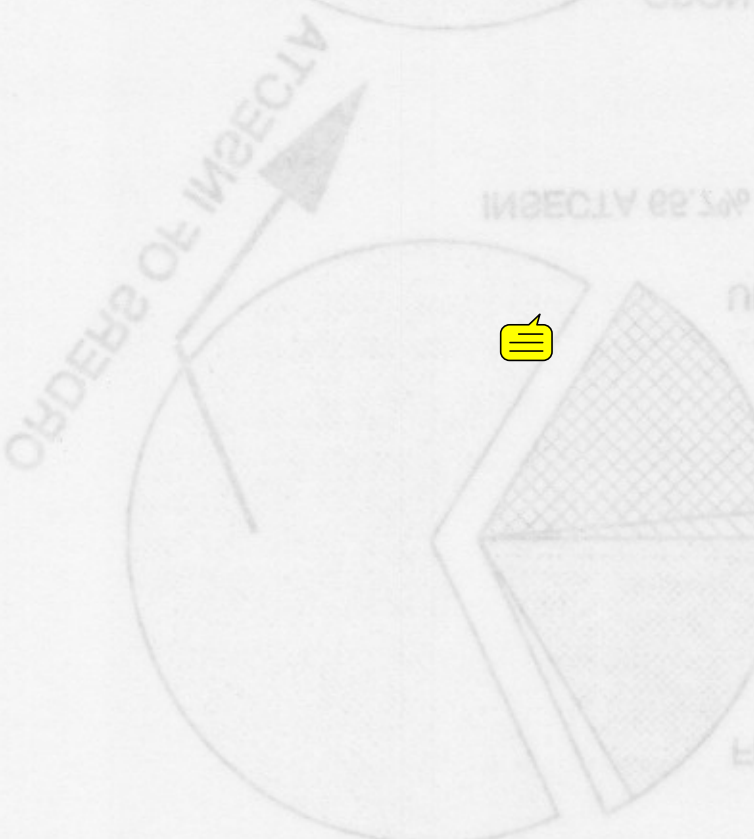


Figure 6. Percentage (by weight) of prey taxa consumed by 40 rainbow trout. Orders of Insecta (percentage of total insects weight) are also indicated.


ORDERS OF INSECTA

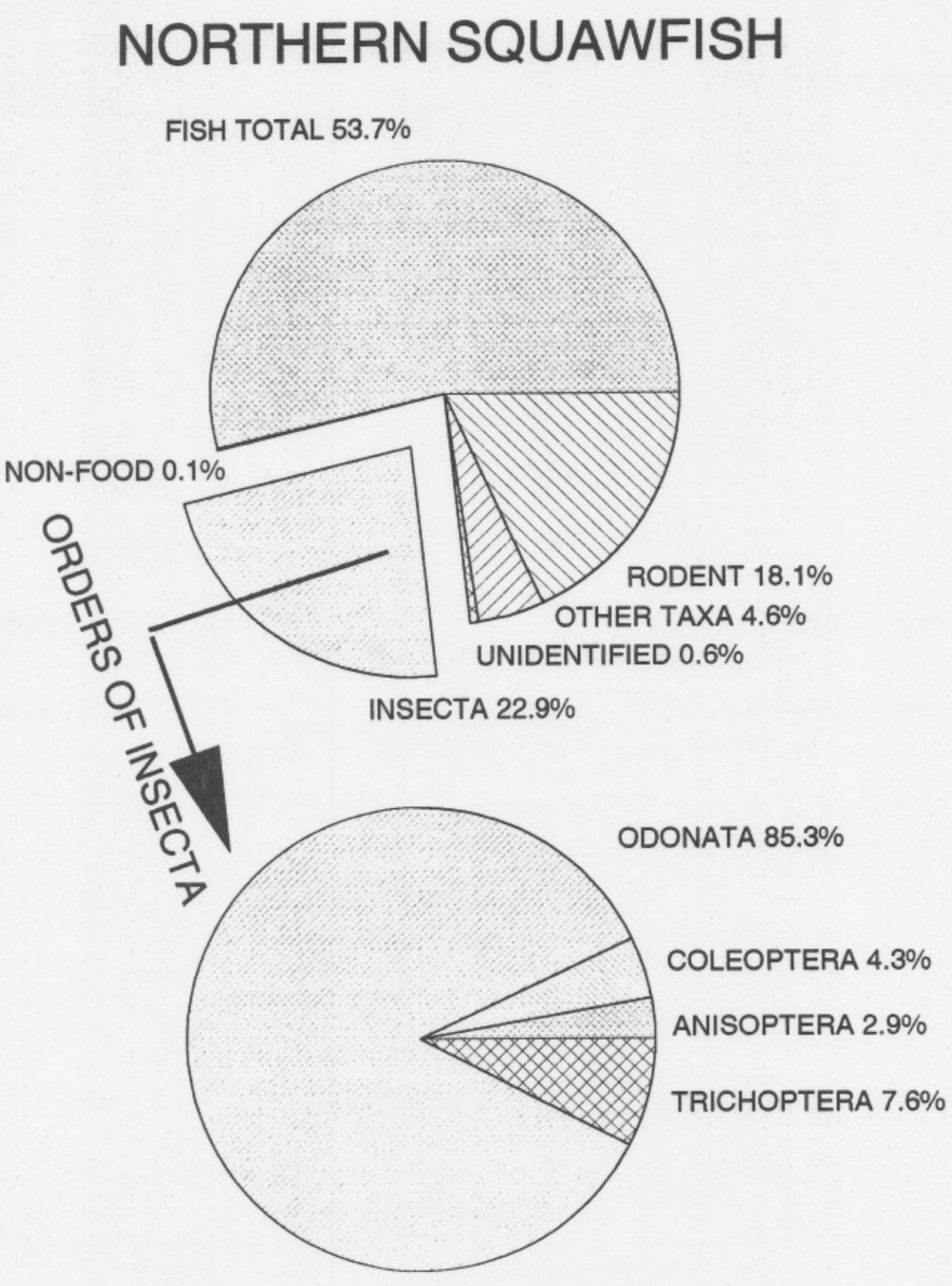
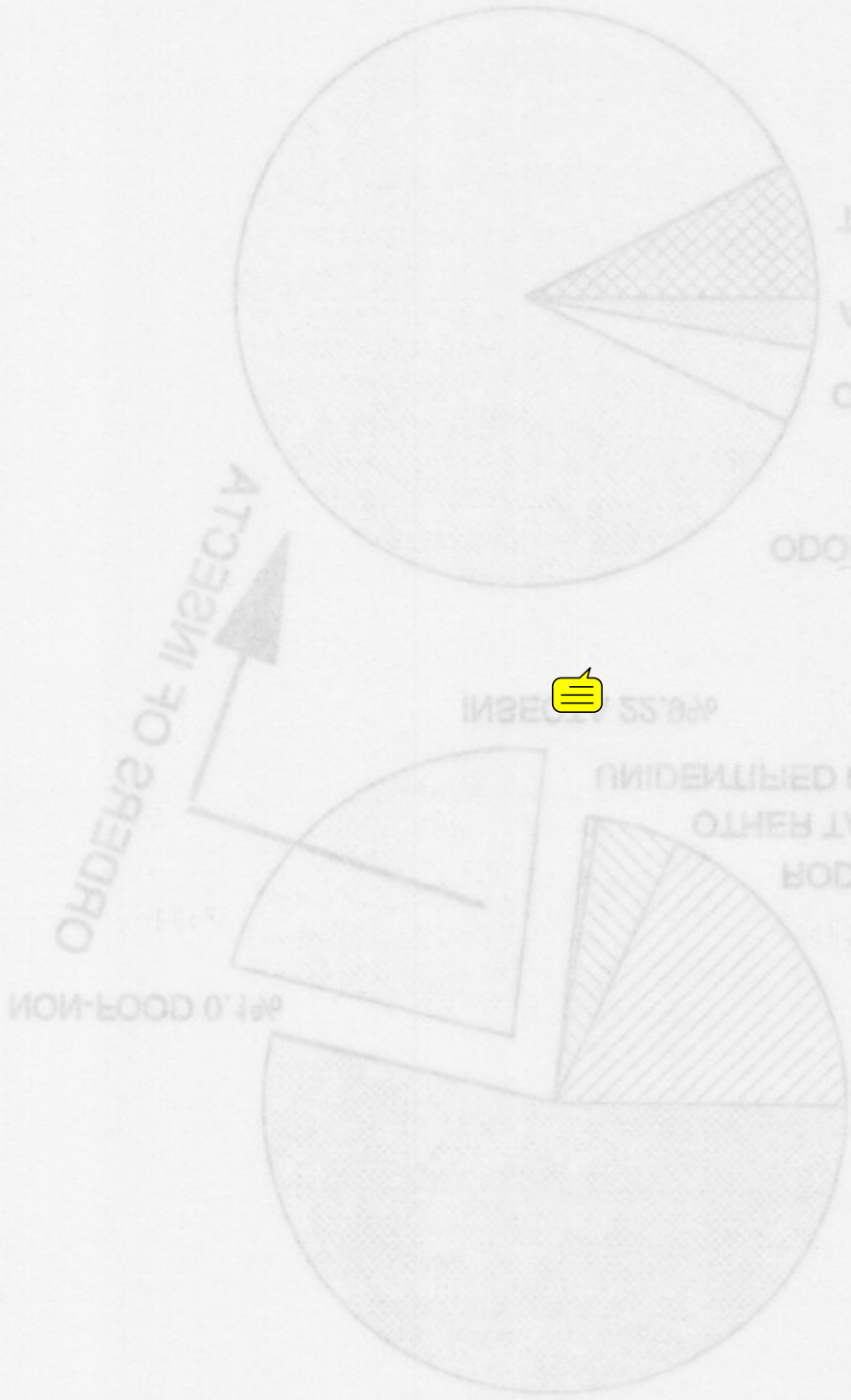


Figure 7. Percentage (by weight) of prey taxa consumed by 24 northern squawfish. Orders of Insecta (percentage of total insects weight) are also indicated.


ORDERS OF INSECTA

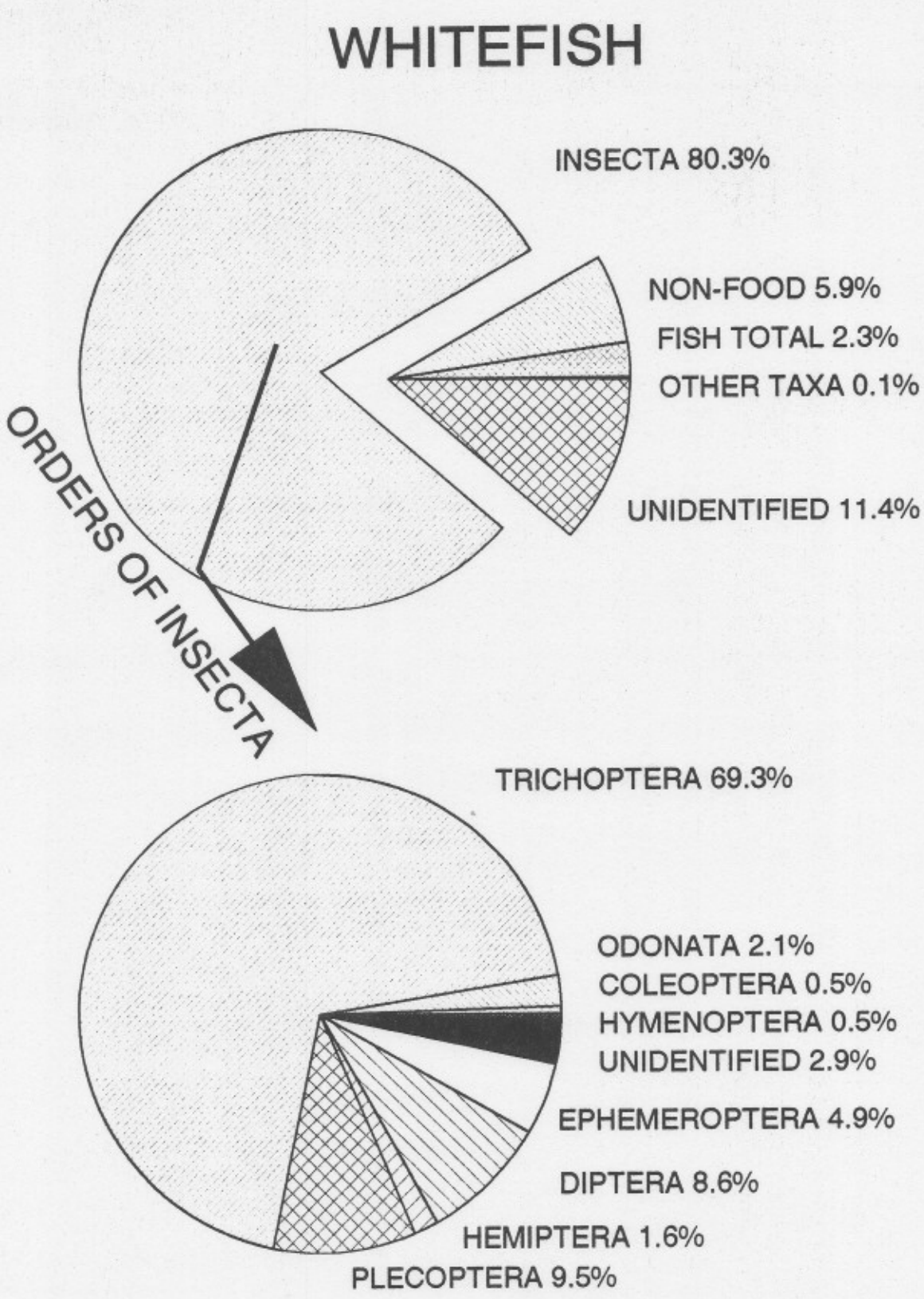


Figure 8. Percentage (by weight) of prey taxa consumed by 20 mountain whitefish. Orders of Insecta (percentage of total insects weight) are also indicated.

ORDERS OF INSECTA

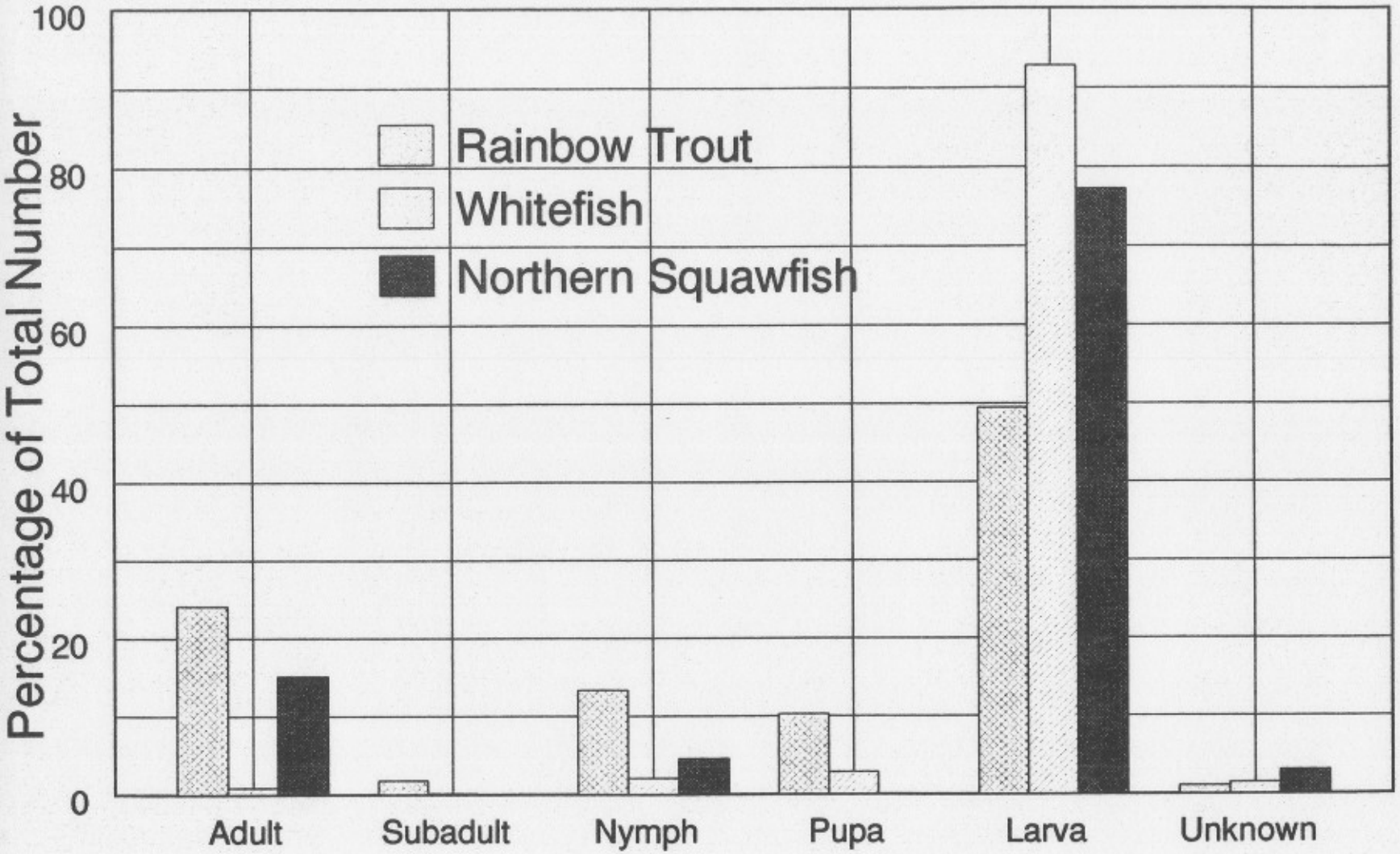


Figure 9. Life stage of insects consumed by rainbow trout, mountain whitefish and northern squawfish. percentages of total number of insects are indicated.