

FOOD HABITS ANALYSIS OF FISH FROM MOUNTAIN LAKES
IN LASSEN VOLCANIC NATIONAL PARK, CALIFORNIA.

by

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March 25, 1977

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West (Food)
NFBIL 49473

Abstract

This investigation was designed to identify primary sources and kinds of food organisms found in stomachs of rainbow (Salmo gairdneri), brown (Salmo trutta), and brook trout (Salvelinus fontinalis) from mountain lakes in Lassen Volcanic National Park.

Organisms were classified according to origin (ie: terrestrial or aquatic) and identified to the family level. Frequency of occurrence and numerical methods were used to analyze data.

Terrestrial and aquatic food organisms dominated stomachs of fish from large and small lakes, respectively. Fish size and condition had no apparent effect on foods consumed, but specialization may have occurred in some instances.

Introduction

Food habits of rainbow (Salmo gairdneri), brown (Salmo trutta), and brook trout (Salvelinus fontinalis) captured from ten lakes in Lassen Volcanic National Park were analyzed. Similarities and/or differences between samples from these and other lakes were noted.

Literature on food habits of fish is abundant. Several classical papers on selective feeding behavior (Hunt, 1975; Galbraith, 1967; Elliott and Jenkins, 1972; and Bryan and Larkin, 1972) provided some insight into possible causes for specialization of certain fish. Long term studies by the California Department of Fish and Game on interspecific relationships of fish in Castle Lake (Swift, 1970; Wales and German, 1956; and Wales, 1946) were helpful in analysis of food habits in this study. Hoar (1942) discussed possible diurnal variations in feeding behavior of different sized fish.

All plant and animal food organisms were identified to family level. Frequency of occurrence and numerical methods described by Ricker (1971) were employed during this study.

Terrestrial food organisms dominated stomachs of fish from lakes larger than fifty acres. Aquatic organisms were of primary importance to fish in smaller lakes.

Size and/or condition of fish had no apparent affect on food consumption in most cases.

Food specialization may have occurred in several instances, but evidence was inconclusive.

Materials and Methods

Rainbow, brown, and brook trout were captured by experimental gill net or hook and line from ten lakes in Lassen Volcanic National Park during a National Park Service study in the summer of 1976. At that time, stomach samples were taken from the fish and preserved in ten percent formalin. Analysis of stomach samples took place between January 1 and March 25, 1977. All stomach contents were examined under ten power magnification. Plants and animals were identified to the family level. All unidentified detrital material was classified according to its origin as plant, animal, or inorganic. Pieces of unidentifiable detritus were lumped into groups of approximately the same volume as the average organism and counted.

Aquatic insects were identified according to the classification scheme used by Usinger (1956). All other aquatic invertebrates and plants were identified using Edmondson's (1959) scheme. Invertebrates of terrestrial origin were identified using the text by Borror and DeLong (1971). Fishes were grouped according to the system presented

by Lagler, et al (1962).

All organisms were enumerated by family, but no attempt was made to use volumetric or gravimetric techniques because of the original study objectives and limited time available.

Data analysis included a combination of the numerical and frequency of occurrence methods as outlined by Ricker (1971). Any differences between stomach contents of different fish species inhabiting the same lake were investigated. The origin of food items was defined as either aquatic or terrestrial. Aquatic items included benthic, pelagic, and surface dwelling organisms.

Results

Fifty-one of the 63 families of food items taken from trout stomachs during this study were insects. Twenty-nine of these insect families were of terrestrial origin (Table 1.) and the remaining twenty-two families were of aquatic origin. Freshwater snails (Gastropoda), Bony Fishes (Osteichthyes), and Clams (Pelecypoda) were found in some stomachs. One leech was found but it may not have been a food item. Water Milfoil (Myriophyllum) was the only plant that was identifiable, but numerous stomachs contained unidentifiable plant, animal, and inorganic detritus.

Fish from the three largest lakes in this study, Butte, Horseshoe, and Snag Lakes, utilized food organisms of terrestrial origin more heavily than fish living in smaller lakes (Table 2.). Ants (Formicidae) were the dominant food organism (by number) found in the stomachs of fish from these lakes (Tables 3, 5, and 10). Midges (Chironomidae), a aquatic Diptera family, were the dominant food organism of fish from Hat, Summit, and Terrace lakes (Tables 4, 11, and 12). Fish in Manzanita and Rainbow lakes fed heavily on mayflies (Tables 6 and 7). The single

Table 1. Family, common names, and origin of food items in stomachs of fish from Lassen Volcanic National Park, California.

Terrestrial Origin

Class INSECTA

Order Coleoptera

Cantharidae - Soldier Beetles
Carabidae - Ground Beetles
Chrysomelidae - Leaf Beetles
Curculionidae - Snout Beetles
Elateridae - Click Beetles
Hydraenidae - Minute Moss Beetles
Orthoperidae - Minute Fungus Beetles
Scolytidae - Bark Beetles
Staphylinidae - Rove Beetles

Order Diptera

Asilidae - Robber Flies
Empididae - Dance Flies
Muscidae - House Flies
Phoridae - Blow Flies
Sarcophagidae - Flesh Flies
Sciomyzidae - Marsh Flies
Tabanidae - Deer Flies
Tephritidae - Fruit Flies

Order Hemiptera

Anthracoridae - Minute Pirate Bugs
Miridae - Plant Bugs

Order Homoptera

Aphididae - Aphids

Cercopidae - Spittlebugs

Order Hymenoptera

Apidae - Bees

Chrysididae - Cuckoo Wasps

Formicidae - Ants

Ichneumonidae - Ichneumons

Platygasteridae - Platygasterids

Pteromalidae - Pteromalids

Vespidae - Wasps

Order Psocoptera

Pseudocaeciliidae - Psocids

Aquatic Origin

Class INSECTA

Order Coleoptera

Dryopidae - Long-toed Water Beetles

Dytiscidae - Predaceous Diving Beetles

Order Diptera

Chaoboridae - Phantom Midges

Chironomidae - Midges

Simuliidae - Black Flies

Thaumaleidae - Solitary Midges

Order Ephemeroptera

Baetidae

Heptageniidae

Order Hemiptera

Corixidae - Water Boatmen

Mesovelidae - Water Treaders

Notonectidae - Backswimmers

Order Megaloptera

Sialidae - Alderflies

Order Odonata

Aeshnidae - Darners

Coenagrionidae - Narrow-winged Damselflies

Gomphidae - Clubtails

Libellulidae - Common Skimmers

Order Plecoptera

Nemouridae - Spring Stoneflies

Order Trichoptera

Hydropsychidae - Net Spinning Caddisflies

Leptoceridae - Longhorned Caddisflies

Limnephilidae - Northern Caddisflies

Phryganeidae - Large Caddisflies

Psychomyiidae - Tube Making Caddisflies

Class ARACHNIDA

Order Acarina

Teutoniidae - Water Mites

Class CRUSTACEA

Order Amphipoda

Gammaridae - Freshwater Scuds

Order Cladocera

Daphnidae - Water Fleas

Macrothricidae - Water Fleas

Class GASTROPODA

Order Basommatophora

Limnaeidae - Pond Snails

Planorbidae

Class HIRUDINEA

Order Rhincobdellida

Glossiphoniidae - Leeches

Class OSTEICHTHYES

Order Clupeiformes

Salmonidae - Trout

Order Cypriniformes

Cyprinidae - Minnows

Class PELECYPODA

Order Eulamellibranchia

Unionidae - Freshwater Mussels

Order Heterodonta

Sphaeridae - Sphere Clams

Table 2. Lake size, fish species, number of stomach samples, percent of stomachs with food, and dominant food organisms from ten lakes in Lassen Volcanic National Park, California.

<u>Lake and Size (acres)</u>	<u>Fish* Species</u>	<u>Number Samples</u>	<u>Percent W/Food</u>	<u>Dominant Organism and Origin</u>
Butte (197)	Rainbow	5	80	Formicidae;Terrest.
Hat (25)	Brook	3	100	Chironomidae;Aquat.
Horseshoe (85)	Brook	15	73	Formicidae;Terrest.
	Rainbow	2	100	No Domin.;Aquat.
	Combined	17	76	Formicidae;Terrest.
Manzanita (37)	Rainbow	29	90	Baetidae;Aquatic
	Brown	12	67	Baetidae;Aquatic
	Combined	41	83	Baetidae;Aquatic
Rainbow (25)	Rainbow	1	100	Baetidae;Aquatic
Ridge (25)	Brook	18	100	Limnephillidae;Aq.
Shadow (25)	Brook	1	100	Notonectidae;Aquat.
Snag (445)	Rainbow	21	80	Formicidae;Terrest.
Summit (25)	Rainbow	25	100	Chironomidae;Aquat.
	Brook	1	100	Salmonidae;Aquat.
	Combined	26	100	Chironomidae;Aquat.
Terrace (25)	Brook	8	100	Chironomidae;Aquat.

* Rainbow Trout (Salmo gairdneri), Brook Trout (Salvelinus fontinalis), and Brown Trout (Salmo trutta).

Table 3. Length, weight, condition, and number of food items eaten by rainbow trout from Butte Lake, Lassen Volcanic National Park. Frequency of occurrence (by number and percent), total number of organisms, and percent of total organisms.

Length (cm)	Weight (gm)	Condition	Plant Detritus	Animal Detritus	Carabidae	Chrysomelidae	Curculionidae	Scolytidae	Staphylinidae	Asilidae	Muscidae	Tabanidae	Tephritidae	Aphididae	Cercopidae	Apidae	Chrysididae	Formicidae	Ichneumonidae	Chironomidae	Corixidae	Mesovelidae	Notonectidae	Limnephilidae
17.1	57.6	1.15	2	107		1	1	2		12								26	1	8	4	1	1	2
19.2	74.4	1.07	3	91			2	3		12	1	1			3	1	1	41		7	2		1	1
19.6	77.6	1.02	11	19		2	1	3		10	1		1	4						18	5		1	2
23.5	118.8	0.92	93	111	1	3	1	1	1	31			2		1			13		10	5			
24.5	184.5	1.26	—	—				EMPT																
FREQ	ENCY (BY	Number)			1/4	3/4	4/4	4/4	1/4	4/4	2/4	1/4	2/4	1/4	2/4	1/4	1/4	3/4	1/4	4/4	4/4	1/4	3/4	3/4
FREQ	ENCY (PERCENT)				25	75	100	100	25	100	50	25	50	25	50	25	25	75	25	100	100	25	75	75
TOTAL	NUMBER				1	6	5	9	1	65	2	1	3	4	4	1	1	80	1	43	16	1	3	5
Percent	of total	#			TR	2	2	4	TR	26	TR	TR	1	2	2	TR	TR	32	TR	17	6	TR	1	2

Table 4. Length, weight, condition, and number of food items eaten by brook trout from Hat Lake, Lassen Volcanic National Park. Frequency of occurrence (by number and percent), total number of organisms, and percent of total organisms.

Length (cm)	Weight (gm)	Condition	Plant Detritus	Animal Detritus	Carabidae	Chironomidae	Thaumaleidae	Baetidae	Heptageniidae	Nemouridae	Limnephilidae	Teutoniidae
11.5	21.5	1.37			1	259	1	2				
13.1	28.1	1.27	1	4		302	6	4	1	1	2	
14.6	38.8	1.26				184		6	1	3		2
FREQUENCY (BY NUMBER)					$\frac{1}{3}$	$\frac{3}{3}$	$\frac{2}{3}$	$\frac{3}{3}$	$\frac{2}{3}$	$\frac{2}{3}$	$\frac{1}{3}$	$\frac{1}{3}$
FREQUENCY (PERCENT)					33	100	67	100	67	67	33	33
TOTAL NUMBER					1	745	7	12	2	4	2	2
PERCENT OF TOTAL NUMBER					TR	96	1	1	TR	TR	TR	TR

Table 5. Species, length, weight, condition, and number of food items eaten by fish from Horseshoe Lake, Lassen Volcanic National Park. Frequency of occurrence (by number and percent), total number of organisms, and percent of total organisms.

Fish Species	Length (cm)	Weight (gm)	Condition	Plant Detritus	Animal Detritus	Inorganic Detritus	Chrysomelidae	Orthoperidae	Scolytidae	Cercopidae	Formicidae	Dytiscidae	Chironomidae	Baetidae	Corixidae	Notonectidae	Teutonidae	Salmonidae	Cyprinidae
BROOK	19.6	90.0	1.20					EMPTY											
BROOK	19.9	87.2	1.13		100%														
BROOK	20.6	93.0	1.00	3	1														
BROOK	22.9	135.3	1.12					EMPTY											
BROOK	23.7	153.6	1.14	7	25		1	1	3		11		3		2				
BROOK	25.0	170.0	1.09		13					1			6	2					
BROOK	25.2	166.2	1.05	2	13						163			1		1			
BROOK	25.6	183.6	1.10		3					7	6		4						
BROOK	25.7	199.8	1.18			1							2				3		
BROOK	26.2	233.4	1.27	1								1					9		
BROOK	26.4	223.8	1.22					EMPTY											
BROOK	27.3	170.6	0.86	3													1		
BROOK	28.8	236.8	0.99		12												2		
BROOK	29.1	243.5	1.02	2	2								1						
BROOK	30.2	304.0	1.07					EMPTY											
RAINBOW	27.9	258.8	1.18		11											1			
RAINBOW	42.2	846.1	1.16	4	20												1		1 FL:50
FREQUENCY (BY NUMBER)							1/13	1/13	1/13	2/13	3/13	1/13	5/13	2/13	1/13	2/13	5/13	1/13	1/13
FREQUENCY (PERCENT)							8	8	8	16	25	8	38	16	8	16	38	8	8
TOTAL NUMBER							1	1	3	8	180	1	16	3	2	2	16	1	1
PERCENT OF TOTAL NUMBER							TR	TR	1	3	77	TR	7	1	TR	TR	7	TR	TR

Table 7. Length, weight, condition, and stomach contents of rainbow trout from Rainbow Lake, Lassen Volcanic National Park.

Length	43.0 cm
Weight	1121.5 gm
Condition Factor	1.40
Plant Detritus	2
Animal Detritus	1
Baetidae	13
Corixidae	1
Notonectidae	2
Aeshnidae	11
Limnephilidae	1

Table 8. Length, weight, condition, and number of food items eaten by brook trout from Ridge Lake, Lassen Volcanic National Park. Frequency of occurrence (by number and percent), total number of organisms, and percent of total organisms.

Length (cm)	Weight (gm)	Condition	Plant Detritus	Animal Detritus	Inorganic Detritus	Sarcophagidae	Formicidae	Chironomidae	Baetidae	Notonectidae	Limnephilidae	Teutonidae	Sphaeriidae
11.2	20.4	1.45	3		1						17	1	
11.8	21.2	1.09	3	14	6	1	1	32			12		
11.9	19.5	1.16	2		1			10			17		
12.1	22.5	1.26	38	15				10			4	23	
13.2	27.8	1.20	4	7							39		
14.3	37.1	1.26	5	13				1			9		
17.3	68.8	1.32	2	18	3			7			25	1	
18.0	67.8	1.16	18	5	11			1			12	1	1
18.3	80.1	1.31	14	7	2			3			12	31	
19.9	101.4	1.28	82	9	7						25	6	
20.1	108.4	1.34	163	108				1			64	3	
20.4	122.3	1.44	55	30	10						24	3	
20.6	117.6	1.34	36	108				1			51	2	
21.1	124.0	1.32	120	13	3			2			30	8	1
22.3	144.3	1.30	240	83	22						68		
26.9	244.1	1.25	30	14							22	21	
29.3	282.4	1.12								9	6		
31.5	356.6	1.14	34	6	9				1	3	6		
FREQUENCY (BY NUMBER)						1/18	1/18	10/18	1/18	3/18	18/18	11/18	2/18
FREQUENCY (PERCENT)						5	5	56	5	11	100	61	11
TOTAL NUMBER						1	1	68	1	12	443	100	2
PERCENT OF TOTAL NUMBER						TR	TR	11	TR	2	71	16	TR

Table 9. Length, weight, condition, and stomach contents of brook trout from Shadow Lake, Lassen Volcanic National Park.

Length	40.0 cm
Weight	985.2 gm
Condition Factor	1.55
Animal Detritus	18
Dytiscidae	1
Notonectidae	20

Table 10. Length, weight, condition, and number of food items eaten by rainbow trout from Snag Lake, Lassen Volcanic National Park. Frequency of occurrence (by number and percent), total number of organisms, and percent of total organisms.

Length (cm)	Weight (gm)	Condition	Plant Detritus	Animal Detritus	Carabidae	Curculionidae	Elateridae	Scolytidae	Staphylinidae	Tabanidae	Anthocoridae	Chrysidae	Formicidae	Platygasteridae	Vespidae	Dryopidae	Chironomidae	Baetidae	Corixidae	Teutoniidae	Gammaridae	Planorbidae
50.0	1440.0	1.15									EMPTY											
16.5	40.0	0.88									EMPTY											
20.5	94.0	1.08	8	480				2					44	2	2		2	7			1	
22.5	113.8	1.00	3	8									4				5			5		
22.9	137.9	1.14		180	10								42				7					
23.0	132.7	1.07	1	19				4			2		16	1			10		1	16		
24.6	148.4	0.98		205				1					58				16		2	1		
25.2	176.5	1.10	9	17				2					19				5		2	1		
25.5	169.2	1.02																			1	
26.0	166.8	0.96									EMPTY											
26.1	193.9	1.09									EMPTY											
26.4	176.2	0.95		8								1	18				8		1	1		
26.7	188.5	0.99	3	36		1	1	2	1	1			26			1			2			
28.0	193.2	0.88	3	19									32				7			1		
28.2	237.9	1.06	1	6					1				2				4	2				
30.0	309.4	1.13	2	4									8									
31.0	286.2	0.96									EMPTY											
31.6	328.4	1.03		7													5			12		1
33.0	407.1	1.10		20				1					3				19			1		
34.5	438.0	1.04		212									111									
38.5	625.7	1.07	1	2									3									
FREQUENCY (BY NUMBER)					1/10	1/10	1/10	6/10	2/10	1/10	1/10	1/10	19/10	2/10	1/10	1/10	11/10	2/10	5/10	8/10	2/10	1/10
FREQUENCY (PERCENT)					6	6	6	38	12.5	6	6	6	87.5	12.5	6	6	69	12.5	31	50	12.5	6
TOTAL NUMBER					10	1	1	12	2	1	2	1	386	3	2	1	88	9	8	38	2	1

Table 11. Length, weight, condition, and number of food items eaten by brook* and rainbow trout from Summit Lake, Lassen Volcanic National Park. Frequency of occurrence (by number and percent), total number of organisms, and percent of total organisms.

Length (cm)	Weight (gm)	Condition	Plant Detritus	Animal Detritus	Carabidae	Chrysomelidae	Hydraenidae	Tabanidae	Formicidae	Dytiscidae	Chironomidae	Baetidae	Corixidae	Sialidae	Coenagrionidae	Gomphidae	Libellulidae	Leptoceridae	Unionidae	Gammaridae	Daphnidae	Salmonidae
11.3	16.4	1.13		2								1										
11.6	18.5	1.20	2	20		1						3			1	1					32	
12.7	24.2	1.18									340	2	3									
12.7	21.0	1.02	2	33								29										
13.1	28.1	1.27	5	15							2	3								2	6	
13.1	30.0	1.37	2	20											2						16	
13.3	14.3	0.63	5	18							3				12							
13.4	26.2	1.10		8	2						217	3	8					1				
13.4	24.4	1.02	2	6							172	4			1					6		
13.5	25.5	1.05			1							4			1					4	122	
13.5	23.7	0.96	3	1							1	53								2	5	
13.7	23.5	0.90		5							166	18										
13.7	28.6	1.11	2	10							262	1									1	
13.9	29.3	1.09	11	25								19			7			6				
14.2	30.1	1.07	2	12								22						1	1	1	2	
14.5	36.8	1.22		1						1	86	1				2						
14.5	33.6	1.12	1	10							1	3			2		2				4	
14.8	32.4	1.00	12	20								8			1						248	
14.8	35.2	1.08	4	40								21			5						16	
14.9	36.0	1.09	2	10							2	14			2		1		2	1	13	

Table 12. Length, weight, condition, and number of food items eaten by brook trout from Terrace Lake, Lassen Volcanic National Park. Frequency of occurrence (by number and percent), total number of organisms, and percent of total organisms.

Length (cm)	Weight (gm)	Condition	Plant Detritus	Animal Detritus	Inorganic Detritus	Carabidae	Curculionidae	Empididae	Phoridae	Sciomyzidae	Miridae	Cercopidae	Formicidae	Platygasteridae	Pteromalidae	Pseudocaeceiliidae	Chironomidae	Simuliidae	Notonectidae	Sialidae	Gomphidae	Hydropsychidae	Psychomyiidae	Teutonidae
14.0	30.4	1.11	6	8	142												47							
14.1	28.2	1.03		14										2	1		53				1			
15.6	40.0	1.04	13	140		1					1		1				1		1	1	2		3	9
15.8	44.1	1.15	5	1																9				
16.0	44.2	1.07	32	215		4						1	4	2		2	12			2				
16.2	45.5	1.07	1	168													30				1			
17.2	51.6	1.02	1	9				1	2	1	1	4					10	1		1		1		
17.5	62.1	1.14	11	163		2	1						1				6		1	1				
FREQUENCY (BY NUMBER)						3/8	1/8	1/8	1/8	1/8	2/8	2/8	3/8	2/8	1/8	1/8	7/8	1/8	3/8	5/8	3/8	1/8	1/8	1/8
FREQUENCY (PER CENT)						38	13	13	13	13	25	25	38	25	13	13	88	13	25	63	38	13	13	13
TOTAL NUMBER						7	1	1	2	1	2	5	6	4	1	2	159	1	2	14	4	1	3	9
PERCENT OF TOTAL NUMBER						3	TR	TR	TR	TR	TR	2	2	2	TR	TR	71	TR	TR	6	2	TR	1	4

fish taken from Shadow Lake had been feeding heavily on surface dwelling backswimmers (Notonectidae) (Table 9). The predominant food organism of the brook trout from Ridge Lake was the case dwelling Northern Caddisfly (Limnephillidae) (Table 8).

Interspecific differences were noted in some of the lakes with mixed salmonid populations.

Discussion

Butte Lake

Ants, although dominant in number, were not the most frequently occurring item in stomachs from this lake. Conversely, the most frequently occurring food items did not compose the major portion of the diet of these fish. There were no apparent relationships between physical and morphological characteristics of fish and the presence or absence of certain food items in the stomach.

Midges (Chironomidae) that were eaten by these fish were primarily in pupal stages and probably readily available to the fish.

The dominance of terrestrial organisms in these samples is indicative of their abundance, better availability with respect to location of the fish, and/or selective or preferential feeding of the fish. Such a small sample of the fish population yields results with dubious reliability.

The only conclusive statement that can be made about the fish in this lake is that at the time they were sampled, most of them had been feeding heavily on foods of terrestrial origin.

Bark beetles (Scolytidae) were found in all stomachs from this lake, and in stomachs of fish from lakes within the same drainage basin. Bark beetles were found in stomachs of fish from only one

lake outside this drainage basin.

Hat Lake

The brook trout in this lake fed primarily on midges (Chironomidae) during the study period.

The morphological features of the lake, specifically shallow depth and fine bottom sediments, are conducive to large populations of this burrowing organism. Most midges were in the pupal stage. At this time when the animal floats up through the water column it is most available to feeding fish.

Some mayflies (Baetidae) were found in each of the three stomachs, but their numbers seem insignificant, relative to the number of midges. The spring stonefly (Nemouridae) is usually found in running water and probably drifted into the lake through an inlet.

I think, from the numbers and life stages of the midges, that they were probably most readily available to the fish at or shortly before time of capture.

Horseshoe Lake

The two rainbow trout taken from this lake had been feeding predominantly on aquatic food items. The larger of the fish had a ^{? * — probably 5 cm,} 50 cm (std. length) tui chub (Cyprinidae) and some detrital material in its stomach. The other rainbow had a relatively empty stomach, containing only one backswimmer (Notonectidae). Neither fish had eaten anything that was commonly eaten by the brook trout in the same lake.

Twenty-seven percent of the brook trout stomachs did not

contain any food. The stomachs that did contain food did not show any type of consistency. One fish fed heavily on ants (Formicidae), but few of the other fish fed on ants at all. Midges and Water Mites (Teutonidae) were utilized about equally, but most other food items were not fed upon with any regularity. Numerous aquatic food taxa were fed upon, but in low numbers. Conversely, fewer terrestrial food taxa were fed upon most heavily with a single taxon making up the bulk of the food.

It should be noted that only several stomachs were very full, the great majority of stomachs were half full or less.

The interspecific relationship between the brook and rainbow trout is complex. Swift (1970) found that wild brook trout derived a smaller percentage of their energy from terrestrial food than rainbow trout did, when the two species lived together in the same lake. But, Wales and German (1956) found that brook trout relied heavily on terrestrial insects when they lived alone.

I believe that both species of fish would rely on a terrestrial food source if there was no interspecific competition. But, at least in this case, it is apparent that the species with the greater population, brook trout, is out competing the less densely populated species, rainbow trout, for the most readily available food source.

On the other hand, the distribution of food organisms may be unrelated to interspecific competition. Hunt (1975) notes that salmonids are opportunistic feeders and this accounts for the diversity of diet and breadth of feeding behavior.

Among the oddities found in stomachs of fish from this lake was a commercial salmon egg.

Bark beetles (Scolytidae) were found, but only in one stomach.

It is interesting to note that frequency of bark beetle occurrence decreased with increasing elevation and increasing distance from the park's northern boundary.

Manzanita Lake

This lake was the richest lake investigated during the study period. This richness was evidenced not only by the abundance of food organisms, but the size range of fish captured and the apparent density of their populations.

Terrestrial organisms made only a minor contribution to the stomach contents of rainbow trout from this lake, and no terrestrial foods were eaten by brown trout.

The major food item in all fish stomachs was mayflies (Baetidae). Rainbow trout also fed heavily on midges (Chironomidae), narrow-winged damselflies (Coenagrionidae), and freshwater scuds (Gammaridae). Water Fleas (Macrothricidae) similar to Daphnia were also fed upon heavily. In addition to feeding heavily on mayflies, the brown trout fed regularly on water fleas, freshwater scuds, large caddisfly larvae (Phryganeidae), and water boatmen (Corixidae).

Populations of mayflies, waterfleas, and freshwater scuds were probably high during the study period, because both species of fish fed extensively on them. Brown trout fed on larger items, excluding the aforementioned ones, than the rainbow trout. Although speculative, I believe that this tendency may be related to the legendary "voracious" feeding habits of the brown trout (Calhoun, 1966). Although some authors (Wales, 1946) believe brown trout feed heavily on fish, no fish were found in these stomachs. This does not eliminate the possibility that they may feed on fish in this lake.

A greater percentage of brown trout stomachs were empty in relation to the percent of empty rainbow trout stomachs. This may be related to diurnal differences in feeding habits of the two species or differences in individual feeding habits. The three smallest rainbow trout had empty stomachs, which may indicate some sort of feeding hierarchy or competitive displacement among these fish. Conversely, it could indicate that these fish were caught before they began to feed and before other fish who had an opportunity to feed. Hoar (1942) found that young salmonids take little food between ten p.m. and five a.m.

The four brown trout that had empty stomachs were fairly large (ie: all larger than 39.7 cm and 910.0 gms.). I cannot speculate on what relationship, if any, exists between fish size and fullness of stomach.

Two rainbow trout stomachs contained water milfoil (Myriophyllum) but I do not think that the fish were feeding on this plant intentionally. I suspect that, because of the density of the plant in the lake, it was ingested while the fish preyed on invertebrates.

Interspecific competition between browns and rainbows in this lake is not evident to me from stomach analysis results.

Other unique or noteworthy food items included bark beetles (the only lake outside the Snag Lake basin with them), houseflies (Muscidae), phantom midges (Chaoboridae) and tube making caddisfly larvae (Psychomyiidae).

Rainbow Lake

The single rainbow trout taken from this lake had been feeding entirely on aquatic organisms. Mayflies (Baetidae) and darners

(Aeshnidae) made up the bulk of the food organisms in the stomach. Although backswimmers (Notonectidae), waterboatmen (Corixidae), and northern caddisfly larvae (Limnephilidae) were present in the sample, none of them composed a significant part of the diet. These results disagree with those of Swift (1970), but Elliott and Jenkins (1972) found that rainbow trout fed on aquatic organisms throughout the entire year.

It is possible that terrestrial windblown drift was low during the period this lake was studied. This would account for the absence of terrestrial organisms in the sample.

It is also possible that this fish specialized on aquatic organisms for another reason. Bryan and Larkin (1972) found that individual food specialization by trout was not uncommon.

No conclusion should be drawn from just one stomach sample.

Ridge Lake

All eighteen brook trout taken from this lake had food in their stomachs. Each of the stomachs contained northern caddisfly larvae (Limnephilidae), in varying numbers. Water mites (Teutoniidae) and midges (Chironomidae) were also found in many of the stomachs, and composed a major portion of the diet of these fish. Sphere clams (Sphaeriidae), backswimmers (Notonectidae), mayflies (Baetidae), flesh flies (Sarcophagidae), and ants (Formicidae) were also found in some stomachs, but did not make up a major portion of the food.

The caddisflies were either very abundant or in a readily available form, or both, when the fish were collected. But, caddisfly larvae found in these stomachs were all casemakers, and therefore living on the bottom of the lake. It does not seem that this type

of animal would be easy to feed on, but selection did seem to be occurring. Although most of the fish fed heavily on water mites and midges, the two largest fish did not. These two fish fed predominantly on organisms larger than midges or water mites. This tendency for size selection in feeding habits was demonstrated by Galbraith (1967) in rainbow trout. Many fishes change their trophic status as they increase in size (Lagler, et al., 19), but selection evidenced by these two fish could be coincidental.

Shadow Lake

The brook trout from this lake had been feeding on backswimmers (Notonectidae). One predaceous diving beetle (Dytiscidae) was also in the stomach. Both of these food items are easily available to fish because they utilize atmospheric oxygen, which means that they must occasionally surface.

It is interesting to note that no terrestrial organisms or small aquatic organisms were eaten by this large fish.

Snag Lake

Food organisms of terrestrial origin dominated rainbow trout stomach samples from this lake. Ants (Formicidae) were eaten by 87.5% of the fish that had food in their stomachs. The ants made up 68% of the total number of organisms in the stomach samples. Midges (Chironomidae) were also eaten regularly by the fish.

Although only two taxa contributed over 83% of the food, of the remaining 17%, aquatic organisms were responsible for the majority. Several unique organisms found were common in other lakes investigated. Common terrestrial organisms were in many of the stomachs, but

uncommon organisms occurred in some samples.

Bark beetles (Scolytidae) were present in only two percent of the stomachs, but ground beetles (Carabidae), snout beetles (Curculionidae), click beetles (Elateridae), and rove beetles (Staphylinidae) were also present. Deer flies (Tabanidae), minute pirate bugs (Anthocoridae), and various parasitic and non-parasitic Hymenoptera were present.

Long-toed water beetles (Dryopidae) and freshwater snails (Planorbidae) were among the unique aquatic organisms found.

Organic detritus was present in many stomachs. Unfortunately the fish from this lake were stored at lake temperature for more than six hours before stomachs were removed. Digestive processes may have continued during this storage period.

Relationships between fish length, weight, or condition and food organisms present in the stomachs were obscure, if they existed.

Summit Lake

Rainbow trout from Summit Lake fed predominantly on the larvae and pupae of midges (Chironomidae). Water fleas (Daphnidae) and mayflies (Baetidae) made up a major portion of the diet of these fish. Although narrow winged damselfly larvae (Coenagrionidae) were not fed upon heavily, they were regularly taken by nearly half of the fish. There was no apparent relationship between fish size or condition and types of aquatic food eaten. Conversely, it seemed that terrestrial foods were eaten mainly by rainbows larger than 16 cm fork length, but the number of terrestrials eaten was low.

This lake was sampled in early fall, and overnight air temperatures were well below freezing. I believe that these low air

temperatures slow the metabolism and movements of terrestrial invertebrates. This may account, in part, for the absence of these organisms from diets of most of the fish.

Alderfly larvae (Sialidae) were found in this lake and only one other lake in the park, Terrace Lake. These lakes are close enough together for these generally poor fliers to travel between. Although these animals were not regularly fed upon, one fish may have "preferred" them.

Three families of damselflies and dragonflies (Odonata) were present in fish stomachs from this lake. Odonata in these three families usually inhabit standing water with a good deal of emergent or submerged vegetation. Their presence indicates these conditions along the lake shore and bottom.

This lake apparently had a diverse selection of aquatic food items available for the fish to feed on.

One large brook trout was captured during the study. The stomach of this fish contained a partly digested trout. Swift (1970) found that brook trout fed primarily on foods originating in benthic zones when they coexisted with rainbow trout. The presence of a food item of pelagic origin in the stomach of this brook trout does not agree with Swift's results. This difference in results could be due to several factors, but drawing any conclusion from only one sample is unsound.

Terrace Lake

Aquatic food organisms, especially midges (Chironomidae) and alderfly larvae (Sialidae), dominated food in stomachs of brook trout from this lake.

Terrestrial food organisms made up less than ten percent of all food eaten by these fish, but during the sampling period fish were very active at the lake surface. There were many terrestrial taxa in these samples, but none were fed upon regularly.

The feeding activity of these fish was probably regulated by the abundance and availability of aquatic food organisms.

Summary

Dominance of terrestrial food organisms in stomachs of fish from large lakes, and aquatic food organisms from small lakes is perplexing. Numerous factors, acting independently or in combination, may be responsible for these results. Air temperatures at time of sampling may have had an influence on activity and abundance of terrestrial organisms at the large lakes. Chemical and/or physical conditions in the large lakes may have been less conducive to aquatic invertebrate production than in small lakes during the study period. Although speculations can be made on this problem, I do not know the reason for these results.

In lakes containing two species of fish there was no consistent relationship between dominant fish species and food organisms consumed.

The most predominant aquatic food organisms were benthic midge larvae and pupae (Chironomidae) and mayfly larvae (Baetidae). These organisms are commonly found in standing water bodies with fine sediment bottoms. Numerous other aquatic food taxa were found in varying abundance in some lakes. Pelagic and surface dwelling aquatic organisms were generally not as heavily fed upon as benthic aquatic organisms.

Although numerous terrestrial taxa were found, several species

of ants (Formicidae) dominated this group of food organisms.

Size and condition of fish usually had no apparent effect on food organisms ingested, but a slight relationship may exist in a few isolated cases.

Food specialization by individual trout may have occurred in several instances, but conclusive evidence for such behavior was not present.

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