MICHIGAN DEPARTMENT OF CONSERVATION
Research and Development Report No. 8*

July 14, 1964

FOOD HABITS OF THE BROOK TROUT, SALVELINUS FONTINALIS IN WEST LOST LAKE, OTSEGO COUNTY, MICHIGAN[1]

By Walter T. Momot

Introduction

Studies of the seasonal variations in the food habits of fishes must continue long enough to distinguish between actual food habits of the fish and cycles of abundance of the organisms used as food. Food habits of the brook trout, in a pothole lake which contained no other fish, were examined. The investigation covered variations in food habits as influenced by shifts in the abundance of food items and increasing age (and size) of the fish.

Methods

The field work was conducted from August, 1962, to November, 1963. West Lost Lake lies within the Pigeon River Trout Research Area, administered by the Institute for Fisheries Research, Michigan Department of Conservation. Tanner (1952) described the limnological characteristics of the lake.

---

* Institute for Fisheries Research Report No. 1694.

[1] This investigation was supported by Dingell-Johnson Project, F-27-R, Michigan.

As brook trout do not reproduce in the lake, it is stocked each year at a rate of 100 trout (mean length, about 5 inches) per surface acre.

During August and September, 1962, and April-September, 1963, members of the staff at the Research Area removed stomachs from all angler-caught fish. In autumn, winter, and spring when the lake was closed to fishing, stomachs were obtained at least every 2 months by collecting fish with an A.-C. shocker or by hook and line. Of 273 stomachs examined, 239 contained identifiable food items.

For monthly periods, when possible, I determined for each food item in the series of trout stomachs the identity, weight in grams, volume in cubic centimeters by displacement of water, and frequency of occurrence. The data were then grouped according to the length of the fish in inches: 5-7 (4.6-7.5), 8 (7.6-8.5), 9 (8.6-9.5), and 10 (9.6 and over). The first and last categories included stomachs from fish that differed more than an inch in length because of the similarity of food items and fewness of stomachs in the group.

Results and discussion

The predominant organisms found in the trout stomachs were: aquatic insects, chiefly dragonfly nymphs (Aeschnidae), midge (Tendipedidae and Culicidae) larvae and pupae, water boatmen (Corixidae); Cladocera (Daphnia longispina); and crayfish (Orconectes virilis). Their occurrence in stomachs varied with the season, by weight and by volume.

In the spring and early summer, from April to July, insects were an important part of the food of the trout. In months of their peak of incidence, May and June, they formed 97% of the total weight and 97% of the total volume of food. The most frequently occurring group of insects were aquatic dipterans, chiefly larvae and pupae, of the family Tendipedidae, and larvae of the family Culicidae (Chaoborus sp.); dragonfly (Aeschna sp.) nymphs; and adult hemipterans of the family Corixidae (Sigara sp.). These groups were present in more than 75% of the trout stomachs; at least 21 different species of insects in eight orders were represented (Table 1). Many of them, however, were seasonally irregular in occurrence and in total numbers present. The percentage frequency of occurrence of insects in the diet of the trout never was less than the August, 1962, low of 56%. It reached its high of 93% in October, 1962, and then declined in August, 1963 to 60%. In spite of irregularities, a seasonal succession in dominance of the various organisms was apparent (Table 2).

In late summer and fall, Daphnia longispina became an important component of the diet of the trout when it composed between 29% (October, 1962) and 44% (October, 1963) of the total weight. The frequency of occurrence of Daphnia was highest in August, 1962, at 69%, it was zero in April of 1963, but rose to a high 68% again in August, 1963. Cyclic use of Daphnia is apparent as for insects (Table 2).

In the winter months, crayfish were an important item of diet and formed as much as 72% of the total weight of food present in

Table 1

List of organisms found in brook trout stomachs from West Lost Lake

- Crustacea
  - Cladocera
    - Daphnidae
      - *Daphnia longispina*
  - Decapoda
    - Cambarinae
      - *Orconectes virilis*
- Insecta
  - Odonata
    - Anisoptera (sub-order)
      - Aeschnidae
        - *Epiaeschna heros*
        - *Aeschna* sp.
      - Cordulinae
    - Zygoptera (sub-order)
      - Coenagrionidae
        - *Ischnura* sp.
  - Hemiptera
    - Notonectidae
    - Corixidae
      - *Sigara* sp.
  - Coleoptera
    - Dytiscidae
    - Hydrophylidae
    - Gyrinidae
    - Chrysomelidae
    - Haliplidae
      - *Haliplus* sp.
  - Diptera
    - Ceratopogonidae
    - Tendipedidae
      - *Tendipes* sp.
    - Culicidae
      - *Chaoborus* sp.
    - Tabanidae
  - Ephemeroptera
    - Baetidae
      - *Ephemerella* sp.
    - Heptageniidae
      - *Heptagenia* sp.
  - Trichoptera
  - Orthoptera
    - Gryllidae
  - Hymenoptera
    - Ichneumonidae
    - Formicidae
  - Homoptera
    - Aphididae
    - Psyllidae
- Arachnoidea
  - Hydracarina
    - Pionidae
      - *Forelia* sp.
- Arachnida
  - Lycosidae

Table 2

Summary of the stomach contents of 239 brook trout, 5 to 12.5 inches long, West Lost Lake, Otsego County, Michigan

(N = number of stomachs, A = percent frequency of occurrence, B = percent weight, C = percent volume)

Year, month	N	Crayfish			Daphnia			Insects			Trout eggs		
		A	B	C	A	B	C	A	B	C	A	B	C
1962													
Aug.	16	12	35	23	69	27	40	56	37	38	..	..	..
Sept.	27	22	33	31	59	22	31	67	45	36	..	..	..
Oct.	14	..	..	..	43	29	48	93	55	36	14	16	16
Nov.-Dec.	14	14	28	22	36	14	15	86	58	63	..	..	..
1963													
Jan.-Feb.	12	25	72	56	50	7	16	58	21	28	..	..	..
March	14	27	51	45	27	10	14	73	39	41	..	..	..
April	20	10	5	4	..	..	..	88	95	96	..	..	..
May-June	15	..	..	..	6	3	3	88	97	97	..	..	..
July	18	5	2	3	57	14	18	86	84	80	..	..	..
Aug.	56	8	24	17	68	32	38	60	44	43	..	..	..
Sept.	25	19	46	41	61	30	31	77	24	28	..	..	..
Oct.-Nov.	8	..	..	..	37	44	43	75	55	51	12	1	5

stomachs during January and February. Only young of the year of the crayfish were found in the stomachs. Just as for the other major groups, occurrence was seasonally cyclical. The crayfish did not occur in October of 1962 or 1963, or in May or June of 1963. The highest frequency of occurrence was in March, 1962, at 27%. Because of cannibalism following attempted spawning by the brook trout, trout eggs were also present only seasonally in the fall (Table 2).

To summarize, in terms of weight and volume, insects were most important in early spring; crayfish, cladocerans, and insects contributed equally to the diet in the early autumn, whereas crayfish were the most important item in the winter.

Comparison of the variation in monthly predation by different size-groups of the brook trout from West Lost Lake further enhances understanding of dietary dynamics. Small fish, 5 to 7 inches long, fed predominantly on the cladoceran (Daphnia longispina) from September till the end of March, on insects from April till June, and in July and August on a mixture of Daphnia and insects. For medium-sized fish, 8 inches long, Daphnia and insects were important components of the diet from August till November. Crayfish occurred only sporadically in September, 1962, and March and August, 1963. Only insects were eaten in April, 1963. In general, insects predominated in the spring and Daphnia, in the fall. For 9-inch fish, Daphnia, insects, and crayfish were all important items in the diet. For trout 10 inches and more in

length, crayfish and insects were the major food items; crayfish predominated in the winter and insects in the spring (Table 3).

On the foregoing data, the trout population can be divided into two ecological categories each having a different trophic pattern with respect to its predation upon and utilization of the food available in the lake. The approximate point of division of these two categories is at a mean length of 8 inches. For fish smaller than 8 inches, the seasonal diet was a combination of Daphnia and insects, with Daphnia important from August to February and insects from March to July. For trout larger than 8 inches, crayfish and insects were important but Daphnia were of minor importance (Figs. 1 and 2).

When considering individual categories of organisms as food items for the trout, most of the crayfish were eaten by large trout, most of the insects, by medium-sized fish, and most of the Daphnia, by the smallest trout. This preferential sequence further demonstrates the trophic pattern prevalent among different size groups within the same population of fish (Figs. 1 and 2).

Some comparisons of food habits can be made between the brook trout and the brown trout (Salmo trutta) for West Lost Lake. Tanner (1952) gave stomach analysis data for 33 brown trout (average length of 9.4 inches) collected in the summer of 1950 when only brown trout were stocked. He found that notonectids comprised 51% by volume of the food. In contrast, my analysis showed that notonectids are hardly utilized by brook trout. Tanner also disclosed that crayfish

Table 3

Summary of food items in the stomachs of 239 brook trout of various sizes

(N = number of stomachs, A = percent frequency of occurrence, B = percent weight, C = percent volume)

Year, month	N	Crayfish A	Crayfish B	Crayfish C	Daphnia A	Daphnia B	Daphnia C	Insects A	Insects B	Insects C
					5- to 7-inch trout					
1962										
Aug.	1	..	..	..	100	11	8	..	..	..
Sept.	4	..	..	..	75	17	19	25	1	1
Oct.	..	..	..	..	..	..	..	..	..	..
Nov.-Dec.	4	..	..	..	100	55	72	50	3	4
1963										
Jan.-Feb.	5	..	..	..	100	86	82	..	..	..
Mar.-Apr.	6	..	..	..	33	79	60	57	38	30
Apr.	2	..	..	..	..	..	..	100	8	7
May-June	3	..	..	..	..	..	..	100	17	17
July	2	..	..	..	100	14	16	100	2	4
Aug.	2	..	..	..	50	3	1	100	1	4
Sept.	1	..	..	..	100	11	9	100	0.5	0.4
Oct.-Nov.	..	..	..	..	..	..	..	..	..	..
					8-inch trout					
1962										
Aug.	9	..	..	..	89	68	66	33	21	23
Sept.	10	10	3	9	60	41	36	80	53	43
Oct.	8	..	..	..	37	52	45	100	58	42
Nov.-Dec.	1	..	..	..	100	45	28	100	2	5
1963										
Jan.-Feb.	..	..	..	..	..	..	..	..	..	..
Mar.-Apr.	3	67	0.3	3	33	17	16	67	22	17
Apr.	1	..	..	..	..	..	..	100	6	6
May-June	2	..	..	..	50	100	100	100	4	4
July	7	..	..	..	57	24	24	100	54	50
Aug.	21	5	1	2	76	48	48	76	37	38
Sept.	9	..	..	..	89	64	62	67	14	23
Oct.-Nov.	..	..	..	..	..	..	..	..	..	..
					9-inch trout					
1962										
Aug.	6	33	100	100	33	21	26	100	79	77
Sept.	11	27	54	63	64	42	45	64	39	41
Oct.	4	..	..	..	75	48	55	100	25	42
Nov.-Dec.	6	..	..	..	..	..	..	100	70	64

(continued next page)

Table 3, continued

Year, month	N	Crayfish A	Crayfish B	Crayfish C	Daphnia A	Daphnia B	Daphnia C	Insects A	Insects B	Insects C
					9-inch trout, continued					
1963										
Jan.-Feb.	3	..	..	..	28	14	18	100	9	22
Mar.-Apr.	2	100	18	17	50	5	24	80	12	15
Apr.	11	..	..	..	..	..	..	100	33	34
May-June	3	..	..	..	..	..	..	100	6	7
July	5	20	100	100	80	41	41	100	14	16
Aug.	20	28	39	12	86	25	28	100	7	14
Sept.	7	10	66	65	85	36	36	40	12	13
Oct.-Nov.	5	..	..	..	37	100	100	37	26	33
					10-inch or longer trout					
1962										
Aug.	..	..	..	..	..	..	..	..	..	..
Sept.	2	100	43	28	..	..	..	100	7	15
Oct.	2	..	..	..	..	..	..	50	8	16
Nov.-Dec.	3	66	100	100	..	..	..	100	25	27
1963										
Jan.-Feb.	4	75	100	100	..	..	..	100	90	78
Mar.-Apr.	3	100	82	80	..	..	..	100	27	38
Apr.	6	33	100	100	..	..	..	100	53	53
May-June	7	..	..	..	..	..	..	100	74	72
July	4	..	..	..	50	21	19	100	29	30
Aug.	13	40	32	34	19	14	15	30	49	45
Sept.	8	37	61	88	12	0.5	0.5	75	78	63
Oct.-Nov.	3	..	..	..	..	..	..	43	74	67

Figure 1. --Analysis by weight percentage of stomach contents of brook trout, 5 to 7 inches in length, from West Lost Lake, August 1962 to November 1963.

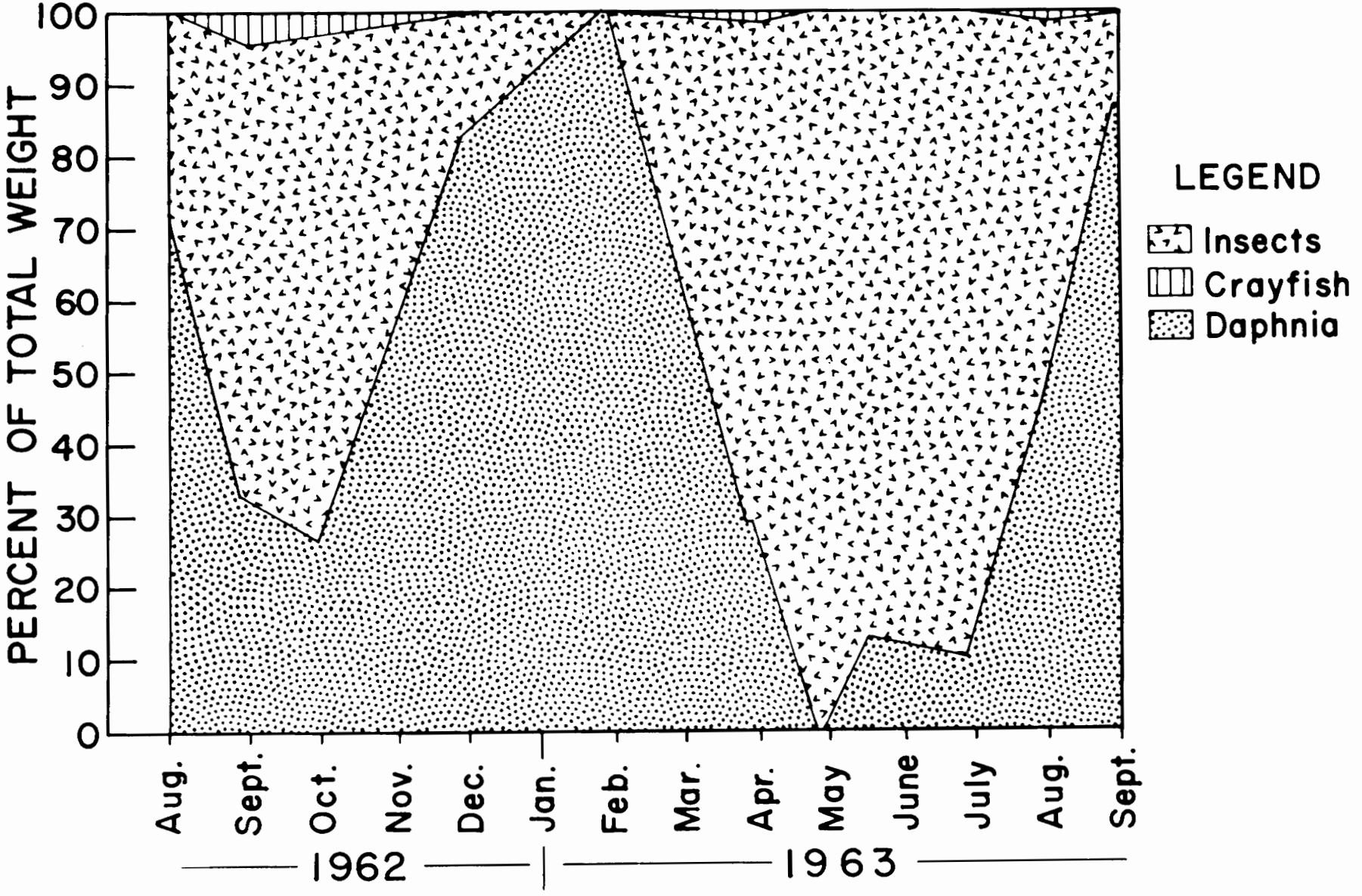
PERCENT OF TOTAL WEIGHT
100
90
80
70
60
50
40
30
20
10
0
Aug.
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
June
July
Aug.
Sept.
1962
1963
LEGEND
Insects
Crayfish
Daphnia

Figure 1

Figure 2. --Analysis by weight percentage of stomach contents of brook trout, 8 to 10 inches (and over) in length, from West Lost Lake, August 1962 to November 1963.

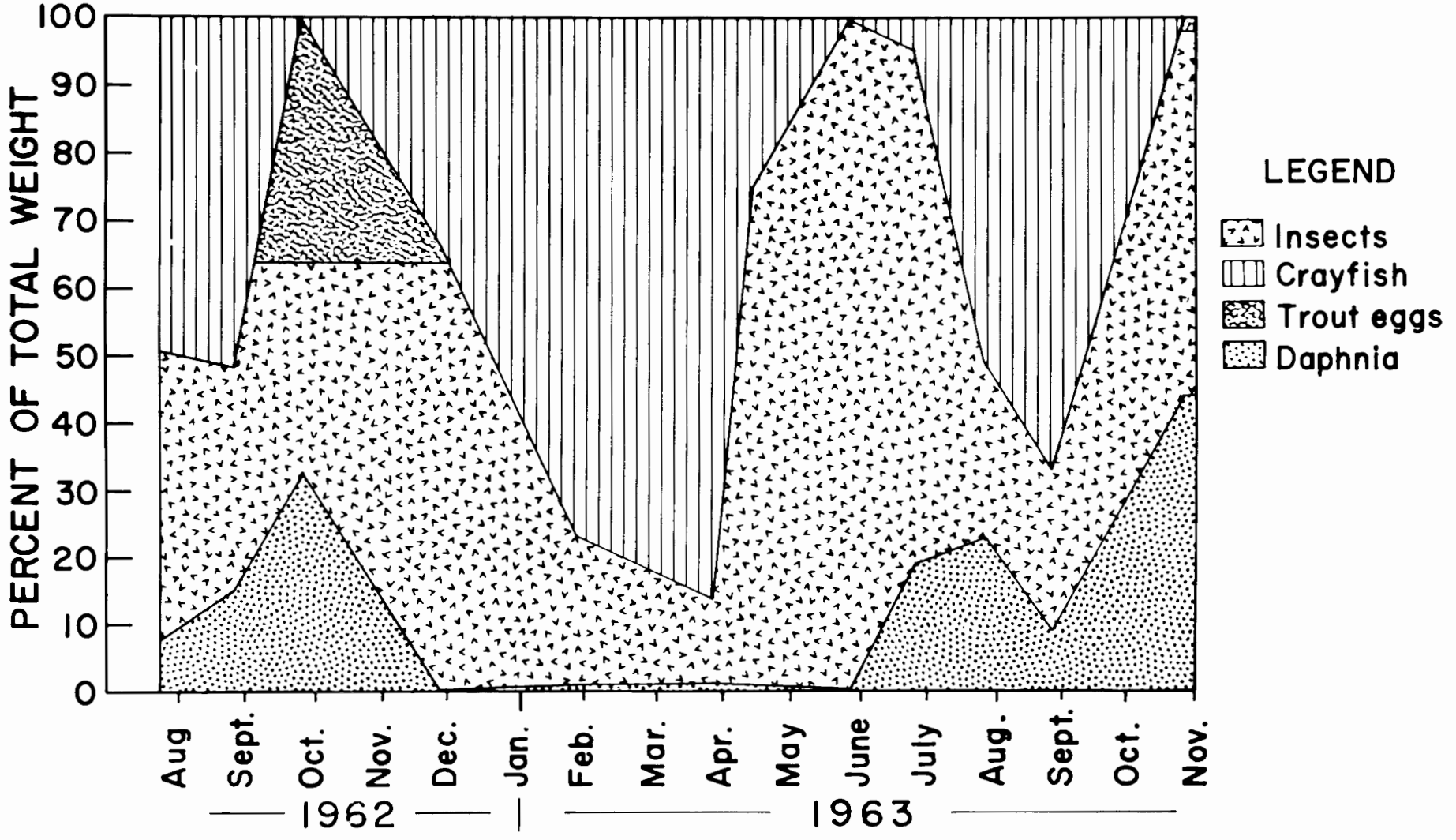
PERCENT OF TOTAL WEIGHT
100
90
80
70
60
50
40
30
20
10
0
Aug
Sept.
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
June
July
Aug.
Sept.
Oct.
Nov.
1962
1963
LEGEND
Insects
Crayfish
Trout eggs
Daphnia

Figure 2

were next to notonectids in importance for the brown trout, forming 22% by volume of the diet. Again in contrast, I found that for 9-inch brook trout, crayfish comprised from 0 to 45% of the diet, and for 10-inch-plus specimens, from 0 to 72%, depending on the time of the year. Regrettably comparison of these two fish species with respect to their utilization of the crayfish population as food is not possible due to lack of data on the brown trout.

Comparisons can also be made between the food habits of other brook trout populations and the one in West Lost Lake regarding the occurrence of crayfish in the diet. For stream trout, Needham (1930) stated that crayfish averaged 32% by bulk of the food eaten by fish averaging 6 1/2 inches in length. Metzelaar (1929), for Michigan stream-caught specimens of the brook trout, gave an average of 15.1% by bulk for crayfish, with a maximum of 22% occurring in July; crayfish comprised 60% of the food of 13- to 17-inch brook trout. For Ontario streams, Ricker (1930) found that the largest percentage of crayfish (31%) was in brook trout 10 to 12 inches long, although they first appeared in individuals 4 to 6 inches long; the food of trout 10 to 20 inches long was chiefly fish and crayfish, with fish more important in the largest trout.

Ricker (op. cit.) reported crayfish to be of little importance in the food of the brook trout in Ontario lakes. The same cannot be said for West Lost Lake, especially for the largest trout. In West Lost Lake, the smallest trout that contained a crayfish was 7.7 inches

long, but only 4 of the 29 trout stomachs that contained crayfish came from fish shorter than 9.1 inches. Ricker has pointed out the importance of fish in the diet of brook trout in Ontario lakes; as West Lost Lake contains no forage fish it cannot be compared in this regard. However in northern Michigan lakes, similar in area and limnology to West Lost, where forage fishes are present, along with stocked brook trout, the forage fishes are not utilized to any great extent by the trout (W. C. Latta, personal communication).

Hazzard (1935) and Juday (1907) studied in detail the food habits of the brook trout in western lakes. Both noted the importance of Daphnia as a food. Apparently crayfish did not occur; at least they are not mentioned. Hazzard found that cladocerans were present in 64.5% of the trout stomachs and formed 44.8% of the volume of food eaten by trout 7.7 to 13.9 inches long. In comparison, for the same month (July) in West Lost Lake, Daphnia contributed 18.0% by volume of food eaten by 7- to 12-inch trout; the peaks were in October, 1962 (48%), and October, 1963 (43%). Juday expressed surprise that specimens of the brook trout 12 to 15 inches long in Twin Lakes, Colorado, contained cladocera. The largest specimen of this trout to contain Daphnia in West Lost Lake was 12.5 inches long but most were between 5 and 7. Perhaps food items larger than cladocera were much less abundant in Twin Lakes than in West Lost Lake.

Conclusions

On the basis of the seasonal trophic patterns observed, the brook trout population in West Lost Lake is clearly divisible into two groups. The dividing point comes approximately at a size of 8 inches. Small fish 5 to 8 inches long, subsist on Daphnia and insects. For large trout, crayfish and insects are the predominant food items and few Daphnia are eaten. Thus, the food habits change as the fish increase in size. Crayfish were eaten mostly by large trout, insects by medium-sized fish, and Daphnia by small trout. Food habits also vary with the season. In terms of weight and volume of items consumed, insects are most important in early spring; crayfish, cladocerans, and insects form an equal share of the diet in early autumn whereas crayfish are most important in the winter.

Literature cited

Hazzard, A. S. 1935. A preliminary study of an exceptionally productive trout water, Fish Lake, Utah. Trans. Am. Fisheries Soc., 65: 122-128.

Juday, C. 1907. A study of Twin Lakes, Colorado with especial consideration of the food of trouts. Bull. Bur. Fish. 26 (1906): 147-178.

Metzelaar, J. 1929. The food of the trout in Michigan. Trans. Am. Fisheries Soc., 59: 146-152.

Needham, P. R. 1930. Studies on the seasonal food of brook trout. Trans. Am. Fisheries Soc., 60: 73-88.

Ricker, W. E. 1930. Feeding habits of speckled trout in Ontario waters. Trans. Am. Fisheries Soc., 60: 1-9.

Tanner, H. A. 1952. Experimental fertilization of Michigan trout lakes. Ph.D. thesis, Michigan State College, 186 p.

INSTITUTE FOR FISHERIES RESEARCH

Walter T. Momot

Report approved by G. P. Cooper

Typed by M. S. McClure