THE UNIVERSITY OF MANITOBA

ECOLOGY OF THE NORTHERN CREEK CHUB, SEMOTILUS ATROMACULATUS ATROMACULATUS (MITCHILL), IN THE MINK RIVER, MANITOBA

by

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A THESIS

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ABSTRACT

Northern creek chub were most abundant in the middle zone (gradient of 7 m/km) of the Mink River. In spring, adults (Age 3^+) inhabited shallow water environments (current > 15 cm/sec, depth < 25 cm) and after spawning moved into slower and deeper waters. Juveniles (age 1-2) were dispersed throughout moderately deep pools and channels (current 0-30 cm/sec, depth 25-50 cm) from spring to early fall. Age 0 fish were found mostly in slow shallow water environments throughout summer. In October, all age classes moved into the deepest sheltered pools (current 0-15 cm/sec, depth > 50 cm, overhanging cover > 10%) where they apparently overwinter. These seasonal changes in abundance between environments were confirmed by following the movements of marked fish.

Diet of creek chub was highly variable due to seasonal differences of availability of food resources. Small chub fed mostly on aquatic insect larvae and terrestial insects, while larger fish (> 50 mm) utilized fewer but larger food items. Food varied from aquatic insect larvae in spring, brook stickleback (Culaea inconstans) in early summer, crayfish in late summer, to frogs and fish in autumn.

Males attain sexual maturity at age IV and live to age VI,

females at age III and live to age V. Adult sex ratio was 1.5 females per male. Spawning occurred during a two-week period starting in mid May when the water temperature first reached 14 C. Males built nests in the gravel substrate of shallow channel environments. Estimates of fecundity were correlated with fork length. Total mature ova per female varied from 1146 - 7539.

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INTRODUCTION

The northern creek chub, Semotilus atromaculatus atromaculatus (Mitchill) is a large cyprinid widely distributed in smaller streams of eastern North America. It is found in the Lake Winnipegosis drainage, and south to New Mexico. In Manitoba, the species is at its most northern distribution (Woody River, 52° 13' N Lat) and this appears to be related to the 65 F July isotherm (Keleher, 1956). It is represented in the eastern part of the Gulf drainage by S. a. thoreauianus Jordan (Hubbs and Lagler, 1967).

Little is known about its ecology. Brief accounts are given on environments occupied (Eschmeyer and Clark, 1939; Minckley, 1956; Trautman, 1957; Cross, 1967), diet (Leonard, 1927; Barber and Minckley, 1971), age and growth (Greeley MS 1930; Dinsmore, 1962; Gunning and Lewis, 1956; Katz and Howard, 1954), schooling behaviour (Kuehne MS 1958), hearing (Kleerekoper and Chagnon, 1954), and geographical variation (Hart, 1952). Breeding behaviour has been well documented (Reighard, 1910; Miller 1964, 1967; Sisk, 1966).

The purpose of this study is to provide information on distribution in the Mink River, relative abundance in particular environments, diet, time and duration of spawning, place of spawning, fecundity, and seasonal movements.

MATERIALS AND METHODS

Description of Study Area

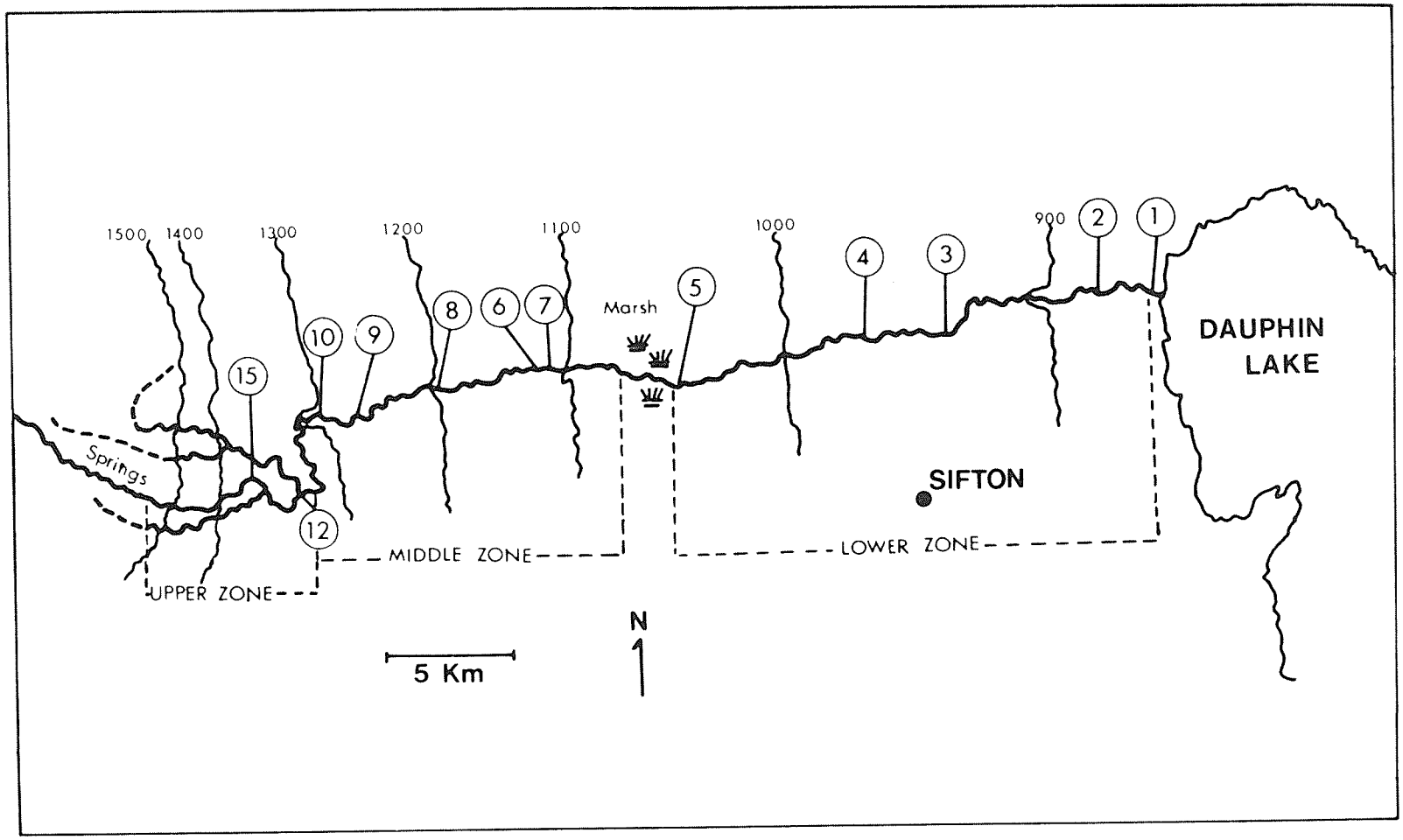
The Mink River originates in the Duck Mountains and flows eastward for 47 km to Dauphin Lake. The stream was divided into three ecological zones (Figure 1) based primarily on gradient, overhanging vegetation, and substrate as follows:

Zone	Gradient (m/km)	Overhanging vegetation	Substrate
Upper	2	much willow and tall grasses	soft(mud-silt)
Middle	7	dense high stands of willow and poplar	variable (sand-rubble)
Lower	3	sparse willow and poplar on high dykes	variable (clay-gravel)

For further details see Appendix 1. The meandering upper zone is contrasted by alternating pools and riffles in the middle zone which empties into a marsh. After 2 km the marsh drains into a high-dyked ditch to Dauphin Lake.

Water discharge varies from 140 cu ft/sec in April to 1 cu ft/sec in late August (Appendix 2). Daily water temperatures vary greatly particularly in the lower zone (Appendix 3). Invertebrates and fishes are most abundant in the middle zone (Gibbons MS 1971). For a check list of fishes refer to Appendix 4. Beavers have substantially changed some sections of the

FIGURE 1. Map of the Mink River, showing the three ecological zones, elevation in feet above sea level, and sampling stations.


1500
1400
1300
1200
1100
1000
900
15
10
9
8
6
7
5
4
3
2
1
12
Springs
Marsh
DAUPHIN
LAKE
SIFTON
MIDDLE ZONE
LOWER ZONE
UPPER ZONE
5 Km
N

stream.

Distribution and Relative Abundance

Northern creek chub were collected at several stations within each ecological zone (Figure 1) to describe their distribution along the river and abundance of different age-groups in particular environments. Age-groups were formed on the basis of length-frequency, age, and sex. Age 0 fish could be distinguished at all times from the older fish by length-frequency (Appendix 5). Age 1^+ fish were aged by the scale method. The range of variation in fork length of the year classes by sex was described (Appendix 6). These fish could be placed into the 3 age-groups using fork length with minimal overlap of year classes between the age-groups as follows:

	Age-group			
	0	1	2	3
Fork length (mm)	< 50	50-80	81-120	> 120
Age of males	0	1	2-3	4^+
Age of females	0	1	2-4	5^+

Seven basic environments were defined (Table 1; plates 1-5) and the densities of each of the above age-groups were estimated from collections of chub made monthly from May to

TABLE 1. Basic environments in the Mink River.

Ecological Factor	Environments						
	Fast shallow channels	Slow shallow channels	Shallow pools	Moderately Deep pools	Slow Deep Channels	Deep Pools	Sheltered Deep Pools
Surface velocity (cm/sec)[a]	>30	15 - 30	0 - 15	0 - 15	15 - 30	0 - 15	0 - 15
Water depth (cm)[b]	<25	<25	<25	25 - 50	>25	>50	>50
Substrate[c]	gravel to coarse rubble	gravel to fine rubble	mud silt to gravel		sand, gravel, rubble	mud-silt to gravel	
Cover[d]	none		none or sparse vegetation	<5% of area with patchy vegetation		5-10% of area	>10% of area

[a]Velocity was measured by timing a floating object.

[a, b]These measurements are exclusive of periods when the river was in freshet.

[c]Characteristics of substrate as described by Lagler (1956).

[d]Overhanging bank, overhanging terrestial and aquatic vegetation, fallen overhanging and submerged trees, branches, and boulders.

PLATE 1. (i) shallow pool

(ii) moderately deep pool

PLATE 2. Slow deep channel

PLATE 3. Sheltered deep pool

PLATE 4. (i) Slow shallow channel

(ii) Fast shallow channel

Spawning nest:

(iii) gravel ridge

(iv) spawning pit

PLATE 5. A deep pool enclosed by a barrier net.

PLATE 6. Creek chub marked with a hyfrecator.

October, 1970. Prior to making a collection in any environment the area to be sampled was enclosed using barrier nets (3.5 mm mesh; plate 5) and then as many fishes as possible were removed using a 1.4 m x 2.0 m seine (3.5 mm mesh) and/or a pulse electro-fisher (Brookmaster MK10, D.C. 12 volts, 8 amps). Chub were anaestetised with MS 222 (tricaine methanesulphonate), measured to nearest mm fork length, sexed (when possible), and placed into recovery tanks before returned to the stream. Scale samples were taken each month for age determination, and some chub were preserved in 10% formalin and later transferred to 40% isopropyl alcohol for analysis of diet.

Diet

Diet of the four age-groups was based on contents of the anterior portion of the intestinal tract from fish collected monthly during the afternoon. Food items were identified at least to family. Wet weight ($\pm$ 0.001 gm) and numbers of each food item in each age-group were recorded.

Reproduction

Adult creek chub sampled from April 28-June 9, 1971 were used as indicators for stages of gonad maturity (Kesteven, 1960), and maturity indices (total gonad weight/total body weight;

Johnson, 1971) to show time and duration of spawning relative to water temperature. Estimates of abundance of ripe chub by sex were made in the basic environments to describe place of spawning and distribution of sexes. Males were distinguished by presence of tubercules. Nesting sites were found and described. Estimates of fecundity relative to length, were made gravimetrically from 40 ovaries collected just prior to spawning. Mature ova were distinguished by their large size, round shape, and yellowish color. Immature ova, and tissue were removed, ovaries weighed ($\pm$ 0.001 gm), and two subsamples of 100 ova were weighed from the randomly mixed eggs. Total number of ova per female was calculated by proportion using the mean weight of the two subsamples (range was $\pm$ 5% of the mean of estimate).

Movements

To study seasonal movements in creek chub, the two branches of the upper zone were divided into sections 0.05 km in length and the basic environments were mapped out between the 6 stations. Chub were taken by seine in August, 1970, and by gillnets (1.3 m x 8 m, 18-60 mm mesh) in May, 1971. Fish age 1^+ so captured at each of the 6 stations were finclipped or marked with a hyfrecator (Owens and Gebhardt, 1968; plate 6), and released into the section of capture as follows:

Marking Period	Method of Marking	Environment fish taken	Number of fish Marked
August 1-3, 1970	Finclipping	slow deep channels and deep pools	345
May 2-16, 1971	hyfrecator	sheltered deep pools	222

For details see Appendix 7. Subsequent sampling in all accessible environments was carried out monthly from September-November, 1970, and May-August, 1971 over a 3-day period. The most effective means of sampling was to seine downstream into a stationary seine placed across the stream. Recaptures were measured, sexed (when possible), recorded to nearest station section, and returned to place of recapture.

RESULTS

Distribution and Relative Abundance

Distribution and abundance along the river

Northern creek chub were most abundant in the middle zone, moderately abundant in the upper zone, and rare in the lower zone (Table 2). Densities of different age-groups varied between basic environments over time (Appendix 8). In the upper zone, creek chub were concentrated in the few areas of gravel and rubble environments, whereas, in the middle zone chub were most common in pools below riffles.

Seasonal distribution and abundance in the basic environments

Young-of-the-year were first observed in early July in shallow pools. After 3-4 weeks they were found in slow shallow channels (Figure 2). In October they were most abundant in margins of deep pools and sheltered deep pools. Towards the end of their first year (April) chub were present in environments similar to October.

TABLE 2. Mean densities of creek chub in the basic environments, and in the three ecological zones of the Mink River, May-October, 1970.

	Ecological Zone														
	Upper					Middle					Lower				
	age-group				area	age-group				area	age-group				area
Environment	0	1	2	3	(m^2)	0	1	2	3	(m^2)	0	1	2	3	(m^2)
Fast shallow channels	-	-	-	-	-	1.0	1.2	2.1	1.8	222	-	-	-	-	18.3
Slow shallow channels	-	-	4.3	-	22.8	22.7	1.9	1.1	-	134.2	-	-	-	-	37.1
Shallow pools	2.4	14.2	-	-	61.9	20.7	3.0	0.9	-	111.9	-	-	-	-	51.0
Moderately deep pools	1.3	0.9	4.5	1.9	186.1	28.9	3.9	6.9	3.1	268.9	-	0.1	-	-	101.0
Slow deep channels	0.8	2.1	3.1	1.8	76.8	7.0	5.5	12.8	13.6	228	-	-	0.3	-	67.2
Deep pools	0.4	0.2	3.6	4.4	179.6	0.6	1.2	3.4	13.4	540.4	-	-	0.2	0.4	50.7
Sheltered deep pools	-	-	6.9	9.9	96.8	7.1	2.3	10.9	6.9	192	-	-	-	-	-
Total area sampled (m^2)			624.2				1697.4					325.5			
Total fish captured			722				3493					6			
Density (fish/10 m^2)			11.6				20.6					0.2			

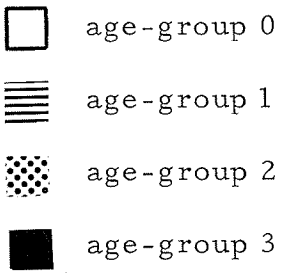
Age-group 1 creek chub were most dense in moderately deep pools from May-September (Figure 2). In October their abundance was greatest in vegetated margins of slow deep channels.

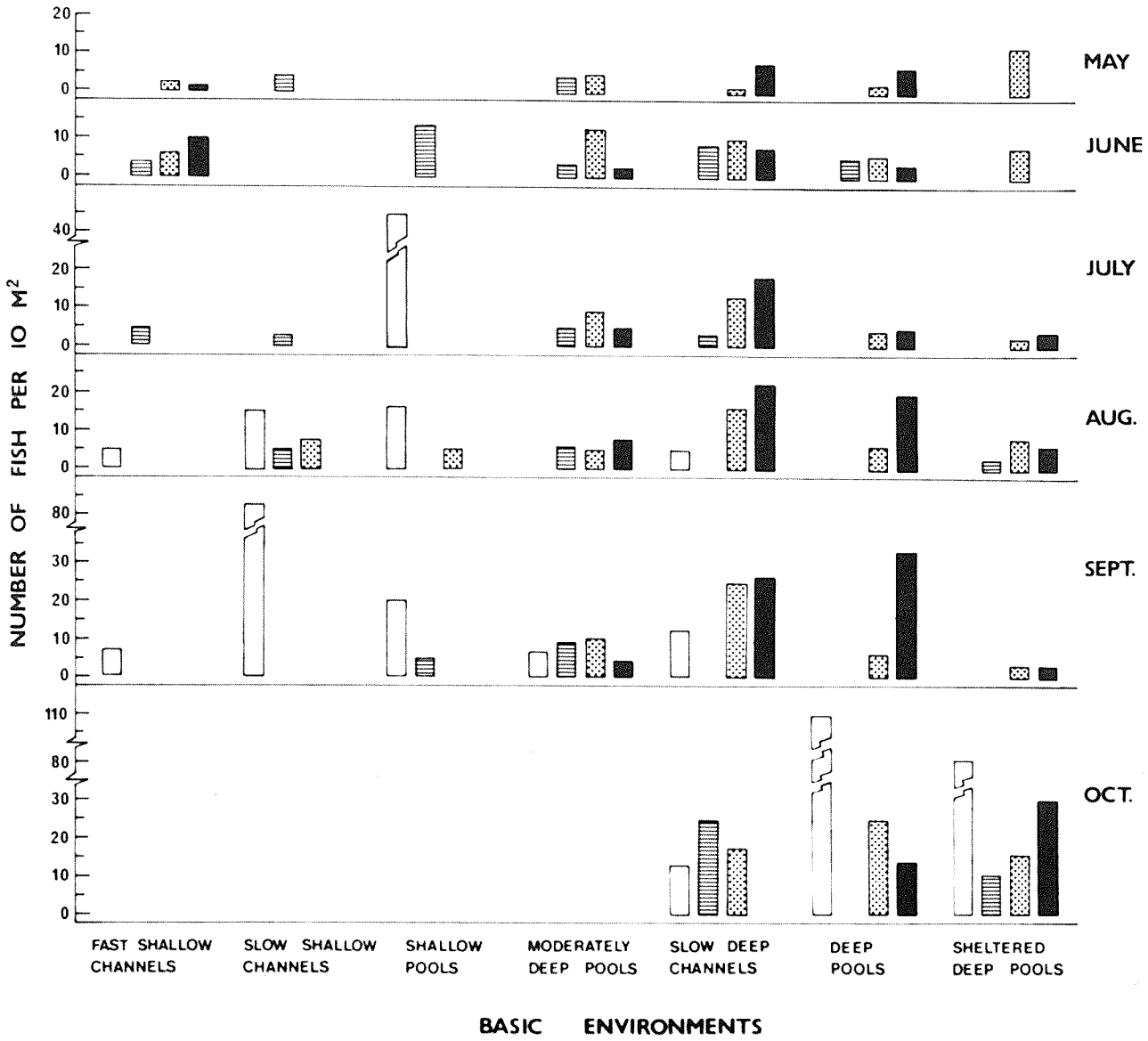
During May-June chub of age-group 2 were most abundant in deep pools, however, some were found in fast shallow channels during the spawning season (late May to mid-June, 1970). After spawning fish moved into slow deep channels. In autumn fish inhabited deep channels and pools (Figure 2). Gillnetting in December, 1970 and April, 1971 indicated that chub were present only in sheltered deep pools.

Adult creek chub (age-group 3) were most abundant in slow deep channels and deep pools from May-September. However, during spawning they inhabited fast shallow channels (Figure 2). By mid-summer large schools of chub occupied the midstream areas of deep pools and slow channels. In October their densities were highest in sheltered deep pools. Similar results were found in December and April.

Although sampling was less extensive in the upper zone (Table 2), creek chub showed seasonal distribution trends similar to the middle zone. Densities were relatively lower in all environments (Appendix 8) even though most fish were found in the relatively few unsilted sections of the stream.

FIGURE 2. Densities of creek chub in the seven basic environments in the middle zone of the Mink River, May-October, 1970.




NUMBER OF FISH PER 10 M²
MAY
JUNE
JULY
AUG.
SEPT.
OCT.
FAST SHALLOW CHANNELS
SLOW SHALLOW CHANNELS
SHALLOW POOLS
MODERATELY DEEP POOLS
SLOW DEEP CHANNELS
DEEP POOLS
SHELTERED DEEP POOLS
BASIC ENVIRONMENTS

Diet

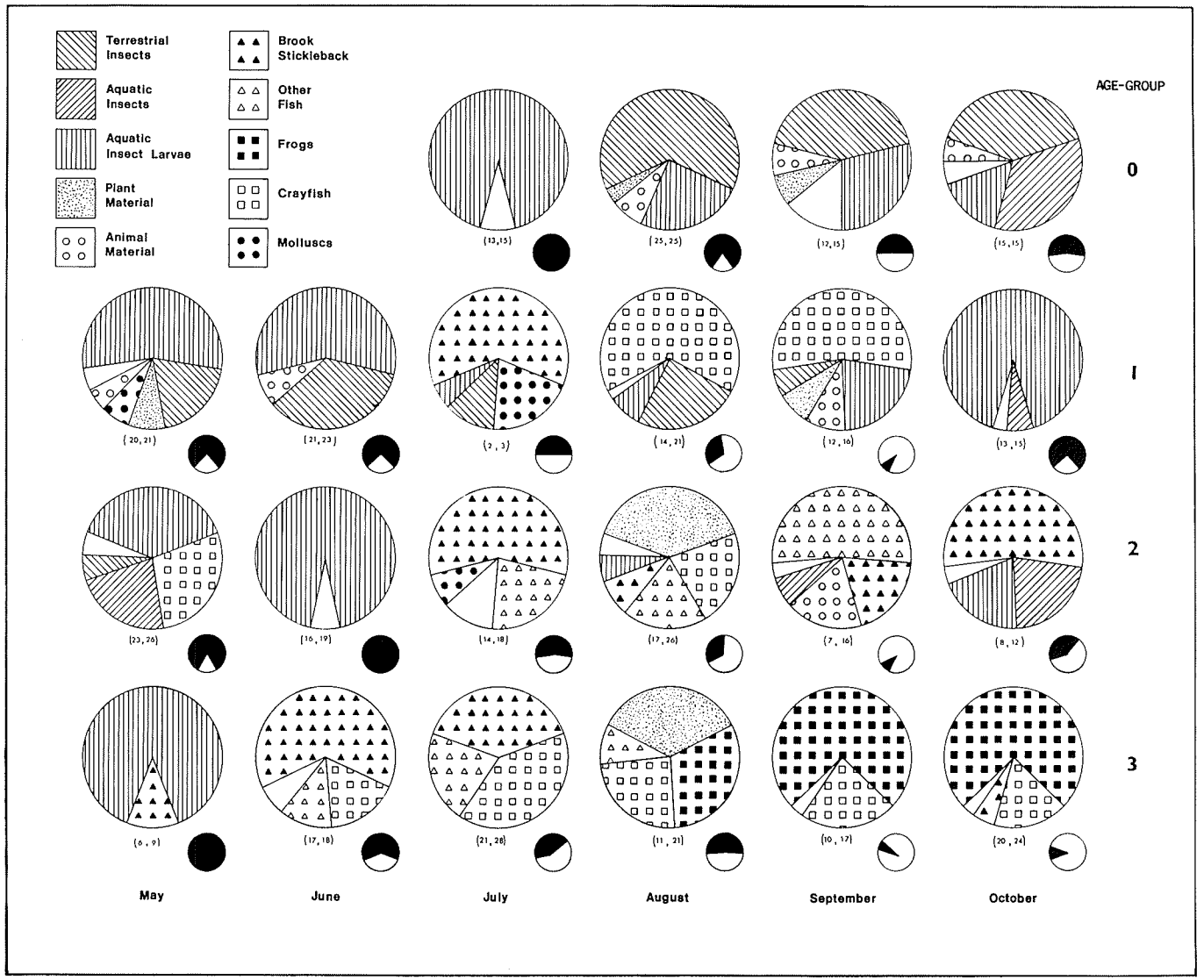
Emphasis is placed on seasonal changes in diet in the different age-groups from the middle zone (Figure 3). Refer to Appendix 9 for details on diet of chub from both upper and middle zones.

In their first month of life all fish of age-group 0 consumed aquatic insect larvae, mostly Tendipedidae and Baetidae. In August-September adult terrestial insects (Diptera, Coleoptera and Hymenoptera) were most common along with the previously mentioned aquatic insect larvae. These same terrestial insects plus adult aquatic insects (Corixidae) were utilized in October (Figure 3).

The major food items of chub in age-group 1 were juvenile aquatic insects (Limnophilidae and Phryganeidae) in May-June, stickleback in July, crayfish in August-September, and juvenile aquatic insects (Tipulidae) in October. Diet of age-group 2 in spring was similar to age-group 1, except that Ephemeridae nymphs were taken. Stickleback constituted the major % weight in July and October (Figure 3). Berries (Cornus, Prunus, Viburnum) and young fish (Etheostoma nigrum) were important in August and September respectively.

Creek chub in age-group 3 fed on larval caddis fly (Phryganeidae and Limnophilidae) in May. Few stickleback were taken in May

FIGURE 3. Diet of four age-groups of creek chub in the middle zone of the Mink River, May-October, 1970. Large circle graphs represent % weight of major food items. Items which contributed less than 5% weight were pooled as others (open section). The smaller circle graphs represent % frequency occurrence (shaded portion) of the major food item. The numbers in parenthesis represent number of stomachs with food and total number of stomachs examined.


Terrestrial Insects
Aquatic Insects
Aquatic Insect Larvae
Plant Material
Animal Material
Brook Stickleback
Other Fish
Frogs
Crayfish
Molluscs
AGE-GROUP
0
1
2
3
(13,15)
(25,25)
(12,15)
(15,15)
(20,21)
(21,23)
(2,3)
(14,21)
(12,16)
(13,15)
(23,26)
(16,19)
(14,18)
(17,26)
(7,16)
(8,12)
(6,9)
(17,18)
(21,28)
(11,21)
(10,17)
(20,24)
May
June
July
August
September
October

but formed the major diet in June-July. Crayfish persisted second in importance from June-October (Figure 3). Berries and seeds were taken in August, and frogs in September-October.

Reproduction

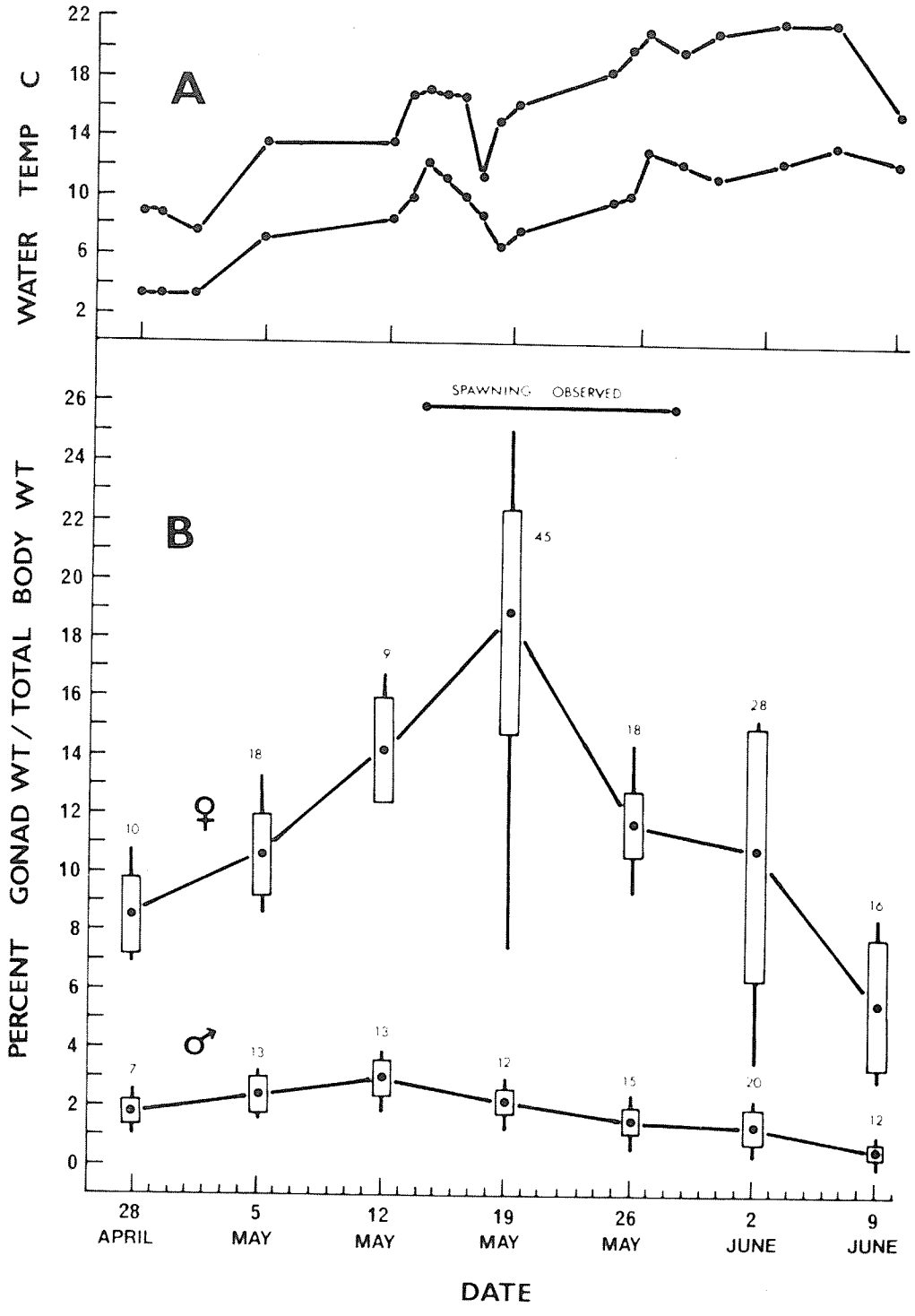
Time and duration of spawning

Spawning activity as indicated by males digging nests commenced on May 14 when the water temperature during the day exceeded 14 C. This activity appeared to cease temporarily on May 17-18 when water temperature in the day dropped as low as 11 C (Figure 4). Spawning activity was first observed around 1200 hours, was most intense between 1600-2000 hours, and declined towards sunset.

The relationship between maturity indices (gonad wt/total body wt) and time is shown in Figure 4. Most females (80%) and males (75%) were ripe on May 19 (Appendix 13) as indicated by an easy flow of eggs and milt. Female maturity indices ranged from 14-25% during spawning, and as low as 3% in post-spawning condition. Values were highest when spawning was observed (May 14-28), but indices for males were highest on May 12 and declined from then on (Figure 4).

FIGURE 4. A. Ranges of water temperature (C) recorded over 24 hour periods at station 7, Mink River, spring 1971.

B. Maturity indices of ripe creek chub at station 7, Mink River, spring 1971. Graph shows means, $\pm$ 1 standard deviation (vertical bars), ranges (vertical lines), and sample size.


A
WATER TEMP C
22
18
14
10
6
2
B
PERCENT GONAD WT / TOTAL BODY WT
SPAWNING OBSERVED
26
24
22
20
18
16
14
12
10
8
6
4
2
0
♀
♂
10
18
9
45
18
28
16
7
13
13
12
15
20
12
28 APRIL
5 MAY
12 MAY
19 MAY
26 MAY
2 JUNE
9 JUNE
DATE

Place of spawning

Prior to spawning (May 12) and after spawning (May 30) both sexes were most abundant in deep pools but absent in slow and fast shallow channels. During the period of spawning both sexes were found in slow and fast shallow channels but males outnumbered females (Figure 5). Nest sites were distributed in the basic environments as follows:

Environment	% of total nests found
Fast shallow channels	55.3
Slow shallow channels	30.6
Shallow pools	8.1
Moderately deep pools	2.0
Slow deep channels	4.0

Total of 49 nests were located. Typical nests (plate 6 and 8) consisted of a ridge of gravel 0.5-2 m long, about 0.25 m wide, and 5 cm high parallel to the current. At the downstream end of the ridge was a spawning pit about 20-25 cm in diameter and 8-20 cm deep (Table 3). With repeated spawnings the male moved the stones from the downstream to the upstream edge of the pit to cover the newly-laid eggs and thus extending the gravel ridge downstream. Male chub were observed digging (plate 9) and defending their nests from other males. Females hastily entered the spawning pit, spawned (plate 10), and

FIGURE 5. Distribution and abundance of ripe female (□) and male (■) creek chub in the various environments of the middle zone during May, 1971. Area sampled in each environment for each period varied from 16.4 - 83.7 m^2. No fish were found in shallow pools. Data for deep pools included sheltered deep pools.

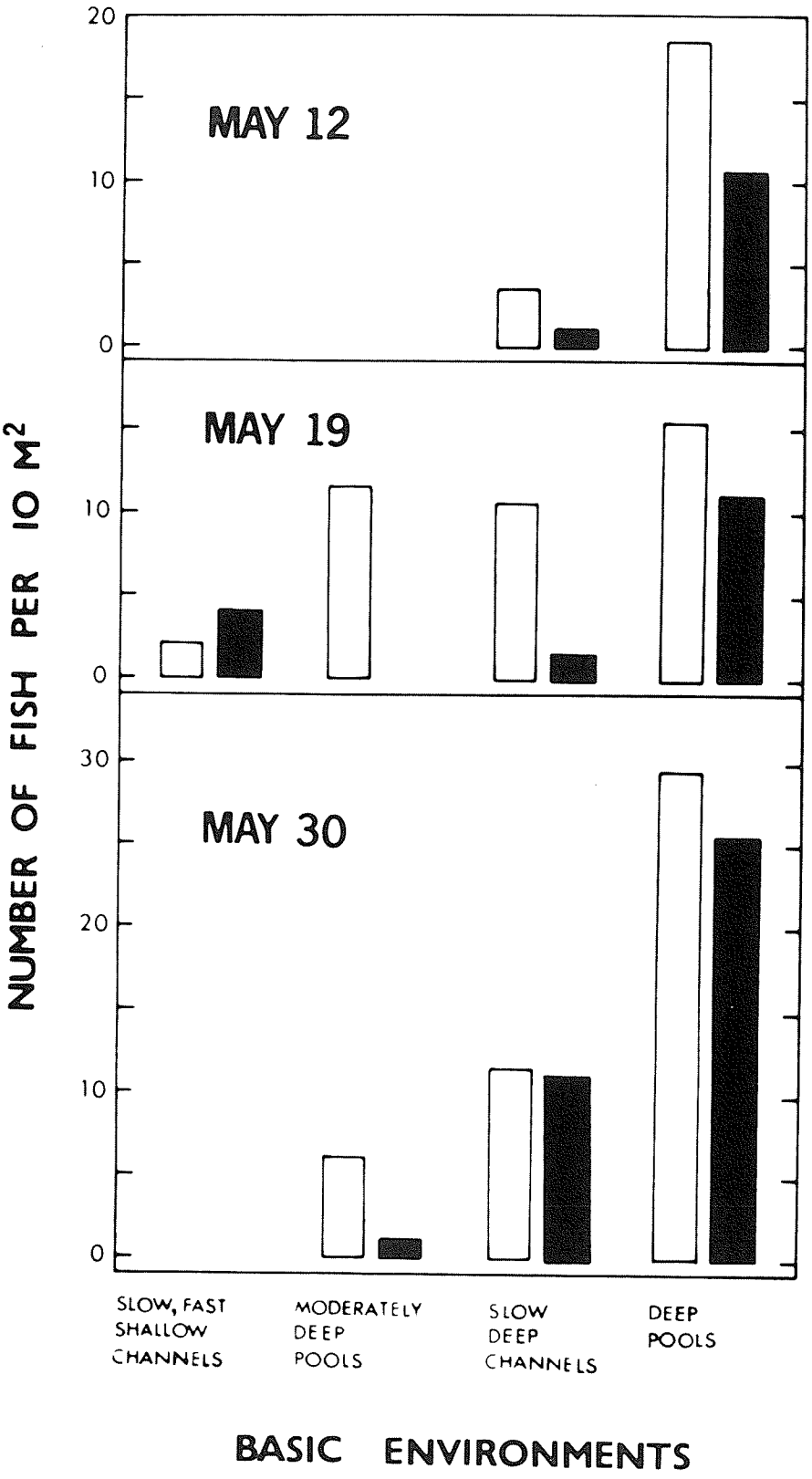

MAY 12
MAY 19
MAY 30
20
10
0
10
0
30
20
10
0
NUMBER OF FISH PER 10 M²
SLOW, FAST SHALLOW CHANNELS
MODERATELY DEEP POOLS
SLOW DEEP CHANNELS
DEEP POOLS
BASIC ENVIRONMENTS

TABLE 3. Frequency of the various parameters used in describing creek chub spawning nests. (n = 11 nests).

Gravel ridge		Spawning pit	
parameter	frequency	parameter	frequency
ridge into current and/or parallel to shore	9	round to oval shape	10
		very irregular shape	1
		depth <8 cm	1
no ridge, between large rubble or under bank	2	8-20 cm	10
		diameter <20 cm	4
width <25 cm	2	20-35 cm	7
25-30 cm	9		
		surface water velocity	
height <3 cm	3	<30 cm/sec	4
3-6 cm	8	30-45 cm/sec	7
length <50 cm	3	substrate[a]	
50-200 cm	8	>50% fine gravel	8
		>50% coarse gravel	2
substrate[a]		>50% sand	1
>50% fine gravel	10		
>50% coarse gravel	1		
>50% sand	-		

[a]Classification of bottom types (Lagler, 1956)

PLATE 7. Ripe female (i and iii) and male (ii and iv) creek chub.

PLATE 8. Spawning nest

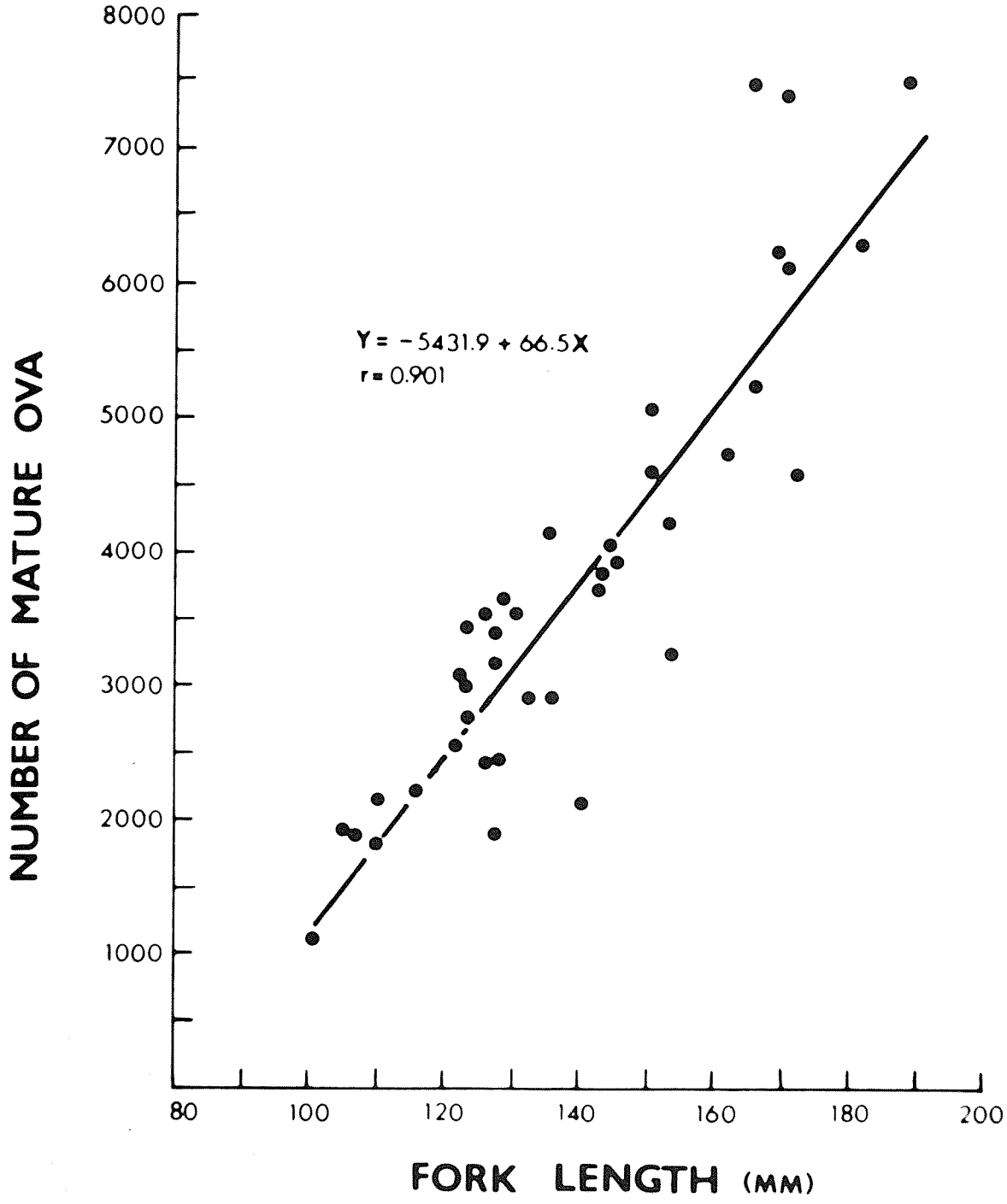
(i) spawning pit

(ii) gravel ridge

PLATE 9. Male chub digging in spawning pit.

PLATE 10. Spawning act - male clasped around female (light-coloured lips).

FIGURE 6. Relationship between number of mature ova and fork length in 40 gravid creek chub from Mink River, May, 1971.


8000
7000
6000
5000
4000
3000
2000
1000
NUMBER OF MATURE OVA
Y = -5431.9 + 66.5X
r = 0.901
80
100
120
140
160
180
200
FORK LENGTH (MM)

retreated into adjacent deeper water environments remaining there for 5-20 minutes before spawning again.

Fecundity

Bagenal (1966) defines fecundity as the number of ripening eggs in fish prior to the next spawning period. Number of ripe ova per female is correlated with length (Figure 6) and varied from 1146-7539. Mature ova were large (1.5-2.0 mm diameter), round, and yellowish, while immature ova were whitish and much smaller (< 0.8 mm diameter).

Seasonal Movements

Creek chub in the upper zone moved most in number and distance during autumn (Table 4). Conflicting data prevents comment on directional movements. Chub were found only in sheltered deep pools in November, and of the fish marked in August, 68% (39 fish) of recaptures moved into there, again indicating that creek chub overwinter in sheltered deep pools. From May-August, 1971, only adult fish were followed. Chub marked in early May were recaptured in slow shallow channels only during the spawning season (Table 4). Fish moved on the average 0.24 km either up or downstream. About 81% of the 22 recaptures that moved out of sheltered deep pools were taken in

TABLE 4. Summary of creek chub movements in the upper zone.

		General movement periods					
Date		Aug. 1-3, 1970		May 2-16, 1971		May 2-16, 1971	
Environment marked		deep pools and slow deep channels		sheltered deep pools		sheltered deep pools	
Fish marked	♀	345 (sex		141		141	
	♂	unknown)		81		81	
Interval of recapture		Sept.-Nov. 1970 Number	%	May-June, 1971 Number	%	July-Aug. 1971 Number	%
Total recaptures		57	16.5	32	14.4	30	13.5
Moved upstream		14	32.6	12	54.5	15	68.2
Mean distance (km)		0.87		0.28		0.42	
Moved downstream		19	44.2	10	45.5	7[b]	31.8
Mean distance (km)		0.49		0.19		0.43	
Complex movements[a]		10	23.2	-	-	-	-
Mean dist.up (km)		0.84		-		-	
Mean dist.down (km)		1.30		-		-	
No movements	♀	14(sex	24.6	6	18.8	3	10.0
	♂	unknown)		4	12.5	5	16.7
Recaptures found by environment:							
1. Slow shallow channels	♀	-	-	6	18.8	-	-
	♂	-	-	11	34.4	-	-
2. Deep pools and slow deep channels	♀	18(sex	31.6	1	3.0	8	26.7
	♂	unknown)		3	9.4	10	33.3
3. Sheltered deep pools	♀	39(sex	68.4	6	18.8	4	13.3
	♂	unknown		5	15.6	8	26.7

[a]movement down one branch and up another.
[b]one fish (excluded from results) moved approximately 15 km downstream.