BOTTOM FAUNA OF THE STREAMS IN THE VICINITY OF RAWALPINDI AS RELATED TO THEIR UTILIZATION BY FISHES

O. Lloyds Meehean and S. Rashid Ali

Zoology Department, Gordon College, Rawalpindi

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The purpose of this investigation is to determine the production of the food organisms per unit area and to correlate the utilization of the fishes to the availability of specific organisms.

The production of bottom fauna by number and weight in generally high in low gradient stations and polluted areas. Productivity of Wah streams and high gradient stations is high as compared to similar type areas in European and American streams. Heavy rains and floods reduce the number of bottom organisms. The study of the gut content of fishes of the same places revealed that 70% of fishes live on bottom organisms.

Introduction

In countries with large populations and limited agricultural lands, protein foods are relatively short. Overgrazing usually results and animal production begins to fall. Properly managed fishing waters, produce many times more pounds of protein than an equivalent area of land. Under natural conditions investigations have shown that the least productive waters have a standing crop of fish between 15 and 20 pounds per acre. In Indonesia, for example, well-managed village ponds may produce up to 8000 pounds per acre.

The intelligent use of fisheries resources depends upon a knowledge of the basic productivity of the body of water. The production of fish can be increased by proper management of the fishery, including proper cropping, the use of right combination of fishes and by the improvement of the stream-bed to increase its carrying capacity. In order to improve the production of fish a systematic study must be made of the factors affecting production for determining the steps required to bring about the desired result. This inevitably includes a study of the food production. The present investigation is the first of its kind in Pakistan so far as the authors are aware, and may serve as a basis for further study or similar investigation in other areas. No published data on the food of fishes in this particular location was found. It is the purpose of these investigations to determine the production of food organisms per unit area, and to attempt to correlate the utilization of the food by fishes to the availability of specific organisms.

The Chemical Character of Water

There have been many studies to relate the chemical contents of the water to productivity, both in Europe and America. Moyle attempted to relate the productivity of the Minnesota fresh water lakes to the chemical, physical and biological indices. He found the total alkalinity and phosphorus to be the most valuable. It is a well-accepted fact that harder waters with high pH are more productive than soft waters.

The West Pakistan Fisheries Department in Rawalpindi have informed the authors that the pH varies from 7.2 to 11 in the Soan River east of Rawalpindi. It is assumed that this is normal in areas of intense sunlight.

The dissolved oxygen ranged from 74 to 150 percent of saturation in the single series of samples collected. The total alkalinity ranged from 177 to 360 parts per million at different sampling stations. According to Ellis this is within the range supporting good fish fauna.

Physical Factors

Rawalpindi is located in the lowlands of the southern Himalayan slope at about 1600′. This slope consists of large alluvial fans where the rivers from ancient glaciers discharged their sedimentary load from the Murree Hills onto the Punjab plains. Between the fans there is a remnant comprising the Tertiary and Pleistocene rocks forming hillocks or ridges between which is Pleistocene looss. This looss may be 200 to 300′ deep in some places and is seriously affected by both wind and water erosion.

The Korang, Gumrah and Ling streams and the Soan River arise in the Murree Hills. The Leh stream starting at Saidpur, and a branch of the Korang starting at Nurpur and the Korang in the vicinity of Rawalpindi, flow primarily through terraced looss until they reach the Soan River where the land is Nagri sand stone and slopes more steeply. The Wah stream and the Haro River north and west of Rawalpindi flow into the Indus river in a westerly direction, while the Soan river east of Rawalpindi flows south-westerly.

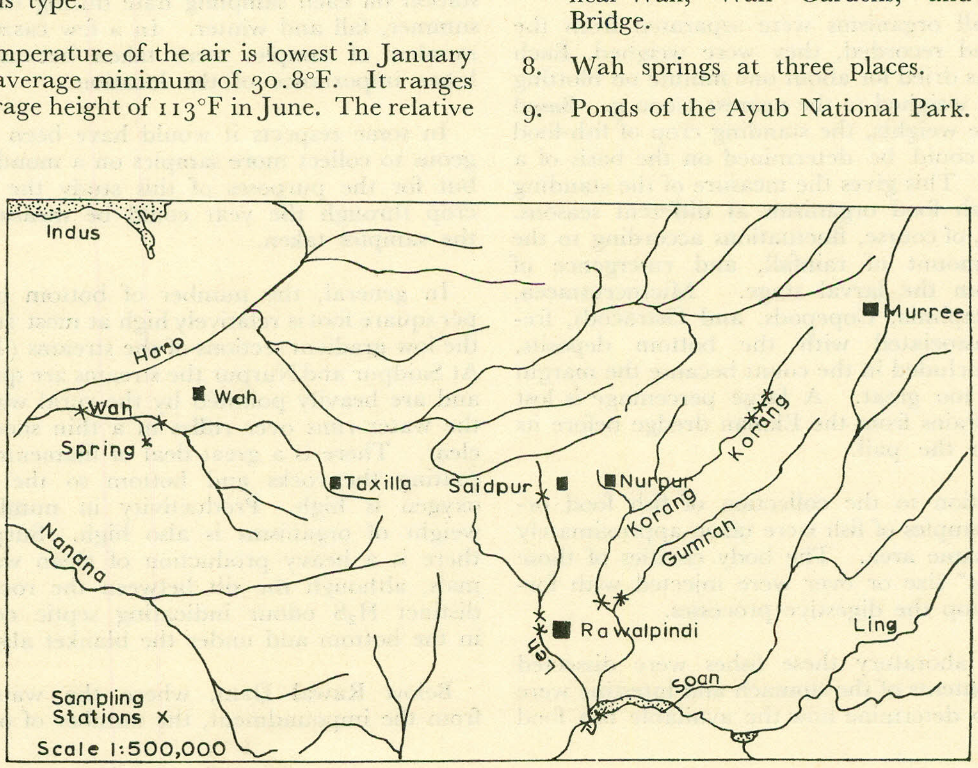
The gradient or the slope of the stream bottom, as well as its geological formation, determines the physical nature of the substratum in the stream and hence its productivity. Our samples are grouped according to the steepness of the slope. Those of the steep gradient or slope, such as the upper Korang and the Soan River have violent run off. The bottom consists of coarse rocks and boulders up to 8′ or more in diameter, with the finer pieces constantly in motion. Even the pools are paved with coarse gravel and small stones with little silt. Streams with the moderate gradient have bottoms consisting of mixed rubble which consists of essentially small stones. They are occasionally affected by violent run off. This is the most productive type of bottom, as is illustrated by samples collected at Saidpur, Nurpur and in the Wah stream. Streams with a lesser degree of slope are called the low-gradient streams. They have sandy or gravelly bottoms with little silt because of the frequency of run off from the surrounding hills. The bottom is unstable during the monsoon season and quite barren at other times. Samples collected in the vicinity of Rawalpindi are of this type.

The temperature of the air is lowest in January with an average minimum of 30.8°F. It ranges to an average height of 113°F in June. The relative humidity is low most of the time, but may average 60 percent in July and August. Water temperature reaches 90°F during the summer months. There are two periods of rainfall. The average rainfall is 36″ per annum.

SAMPLING STATIONS

The locations of sampling stations are shown on the accompanying map. The following are sampling stations:

1. The Korang stream at Salgran, 20 miles, Chatter 18 miles, Gulpur 16 miles from Rawalpindi.
2. The stream below the Rawal Dam.
3. The Korang and Gumrah Streams crossing the Lethrar Road.
4. The Leh Stream at Saidpur, near the Holy Family Hospital and Dhok Dalalan.
5. Nurpur Stream.
6. The Soan River crossing the Grand Trunk Road, above and and below the confluence of the Leh.
7. Wah stream at three places; under the bridge near Wah, Wah Gardens, and Chablat Bridge.
8. Wah springs at three places.
9. Ponds of the Ayub National Park.



Materials and Methods

A surber square foot sampler was used for collection in riffle area. An attempt was made at each location to collect samples with Ekman dredge in pool areas also. At three stations, that is, the Korang and Gumrah streams crossing the Lethrar Road and the ponds of Ayub National Park only Ekman dredge was used.

The bottom samples were washed through the sieves to separate the silt gravel or debris. This concentracted sample contained debris along with bottom organisms which are the food of many fishes. It was preserved in formalin in eight oz. or larger bottles for further study. Collections on any given date included two or more samples.

Concentrated samples were washed to remove formalin in the laboratory All the animals were picked out by placing the sample in petri dishes under binocular microscope. They were indentified and recorded by numbers on a card for each sample. Mostly they were identified to the convenient class or genus to reduce the amount of taxonomic work. This is sufficient identification for the purpose intended by the authors. These samples are available for further study of the taxonomy or the distribution of the species. Each sample of the animals was preserved as an individual sample in vials.

When all organisms were separated from the sample and recorded, they were weighed. Each sample was dried for about one minute on blotting paper and weighed to the nearest 1/000 g. Based upon these weights, the standing crop of fish-food organism could be determined on the basis of a unit area. This gives the measure of the standing crop of fish food organisms at different seasons. There are, of course, fluctuations according to the season, amount of rainfall, and emergence of insects from the larval stage. Microcrustacea, such as Daphnia, Copepods, and Ostracods, frequently associated with the bottom deposits, were not included in the count because the margin of error is too great. A large percentage is lost as water drains from the Ekman dredge before its transfer to the pail.

In addition to the collection of fish food organisms, samples of fish were taken approximately from the same area. The body cavities of those having a 4″ size or over were injected with formalin to stop the digestive processes.

In the laboratory these fishes were dissected and the contents of the stomach and intestine were studied (to determine how the available fish food organisms were being utilized). The gut contents were recorded according to what is predominant in the descending order very abundant, common, or present. The identification was made to families or genera, or other convenient classification to keep the taxonomic work to a minimum. Each fish was recorded separately according to species and length and the contents of the gut.

When the data were analysed, they were separated in two ways firstly, in the order of predominance in each specimen with a list of those organisms that were present. Secondly, the data were analysed according to the frequency with which the individual organisms occurred in individual fishes of the same species and size groups. The frequency with which they are utilized by different fishes is not necessarily related to their predominance in individuals. Frequency of use gives an estimate of the popularity of the general utilization of the food organism. The analyses were also separated according to the length of fishes. Our series of fishes is not extensive enough to show the change in food habits normally expected in different size groups within the same species.

STANDING CROPS OF BOTTOM ORGANISMS

A total of 125 samples from the bottom were collected covering a complete year for each station. Two or more samples were collected at each station on each sampling date during the spring, summer, fall and winter. In a few cases a lesser number of samples were taken because of the lesser importance of the location.

In some respects it would have been advantageous to collect more samples on a monthly basis, but for the purposes of this study the standing crop through the year could be measured with the samples taken.

In general, the number of bottom organisms per square foot is relatively high at most stations in the low gradient sections of the streams (Table 1). At Saidpur and Nurpur the streams are quite small and are heavily polluted by the rural wastes. Yet the water runs over riffles in a thin sheet and is clear. There is a great deal of filamentous algae coating the rocks and bottom so the dissolved oxygen is high. Productivity in numbers and weight of organisms is also high. Surprisingly, there is a heavy production of clean water animals, although the silt between the rocks has a distinct H_2S odour indicating septic conditions in the bottom and under the blanket algae.

Below Rawal Dam, where the water seeps from the impoundment, the number of organisms per square foot is high. The samples collected in September show a decided reduction, probably because of the flood waters overflowing the dam during the monsoons. The population begins to recover in December.

In the Korang stream at Lethrar Road the number of organisms drops off after April. Two factors may be involved. The instability of the bottom during the monsoon rains, and stagnation during periods of low flow. This is reflected by the large percentage of organisms which are air breathers such as the gastropods and the oilgochetes. Continuous turbidity might also have some effect.

Table 1.—Number of Organisms per Square Foot. Low Gradient Stations.

Location	Organism	February March	June	August September	December
Saidpur	Planarians	11	23	0	39
	Oligochetes	0	878	31	8
	Ephemerida	25	18	18	65
	Trichoptera	40	8	5	8
	Chironomidae	157	2388	100	364
	Other diptera	2	10	1	4
	Gastropods	8	744	0	105
	Lamelli branches	2	2	0	0
	*Other organisms	0	30	0	500
Total for all organisms		245	4101	155	643
Nurpur	Planarians	2	0	2	4
	Oligochetes	2	1	39	217
	Ephemerida	765	466	112	195
	Trichoptera	55	17	5	50
	Chironomidae	51	6	23	8
	Other diptera	4	6	0	3
	Gastropods	0	1	0	0
	*Other organisms	2	13	1	16
Total for all organisms		881	529	314	593
Below Rawal Dam	Planarians	112		5	71
	Oligochetes	139		20	20
	Ephemerida	45		14	98
	Trichoptera	309		1	187
	Other diptera	113		0	14
	Gastropods	119		10	13
	Lamellibranches	1		0	19
	*Other organisms	472		13	266
Total of all organisms		1309	—	63	688
Korang Lethrar Rd.	Oligochestes	340	7	70	0
	Ephemerida	76	0	0	0
	Trichoptera	20	0	12	0
	Chironomidae	580	0	58	0
	Other diptera	4	0	58	0
	Gastropods	84	23	112	128
	Lamellibranchs	14	1	48	4
	*Other organisms	64	7	36	0
Total for all organisms		1182	38	396	132

*Organisms other than those listed as key organisms.

At these selected stations where the gradient is high, different results were obtained. The principal production is Ephemerida, Trichoptera, and Chironomidae. These are clean water forms, such as Caenis and Baetis, which depends upon high dissolved oxygen. There is a decided increase in Oligochetes and Chironomidae below the confluence of the Leh and the Soan rivers reflecting the added organic load loaded to the river by heavy pollution of the Leh. There is reduction in these forms in September, immediately after the monsoons. It is difficult to see any definite pattern of emergence probably because the organisms were not identified species wise. It is frequently found that one species replaces another in the yearly cycle.

The Wah stream (Table 3) is an entirely different type of habitat. The gradient is moderate, the water is generally a clear spring water, and the watershed is vast. There may be considerable flooding at times, but no violent scouring. The animals collected reflect stable stream habitat. Most of the stream is riffled with small rocks and gravel bottom.

The stream at the bridge above the springs receives all of the waste from the Wah Cantonment. The bridge is a few miles below the Can-

Table 2.—Number of Organisms per Square Foot. High Gradient Stations.

Location	Organism	March	April	June July	Sep.	Dec.
Korang Stream 16 Mile up	Oligochetes	2	41	14	2	17
	Ephemerida	90	58	15	2	72
	Trichoptera	8	5	2	—	9
	Chironomidae	18	26	4	4	122
	Other diptera	0	0	0	0	11
	*Other organisms	11	13	3	0	0
Total for all organisms *		121	163	38	8	231
Soan river above Leh	Oligochetes	2	4	2	0	4
	Ephemerida	4	13	19	0	12
	Trichoptera	2	1	38	0	3
	Chironomidae	28	11	2	1	259
	Other diptera	3	0	0	0	0
	*Other organisms	0	3	44	10	113
Total for all organisms		39	32	240	11	391
Soan River Below Leb	Oligochetes	2	1185	8	0	1152
	Ephemerida	7	14	7	1	56
	Trichoptera	1	1	0	0	0
	Chironomidae	142	562	13	2	1935
	Other diptera	0	15	0	0	0
	Other orgrnisms	5	47	30	20	1863
Total for all organisms		157	1824	258	23	5012

*Organisms other than those listed as key organisms.

TABLE 3.—NUMBER OF ORGANIMS PER SQUARE FOOT. MODERATE GRADIENT—WAH DRAINAGE.

Location	Organisms	March	May	June	Octo-ber	De-cem-ber
Wah Stream above Springs	Planarians	40		0	0	13
	Oligochetes	15306		167	116	15885
	Ephemerida	130		23	134	232
	Trichoptera	27		5	15	116
	Chironomidae	327		189	572	1179
	Other diptera	302		8	24	99
	Gastropoda	741		0	0	116
	Lamellibranchs	278		14	15	33
	*Other organisms	125		27	35	0
Total for all organisms		17276		433	911	17673
Small spring	Planarians	0		4	1	4
	Oligochetes	0		2	3	56
	Ephemerida	0		3	12	0
	Trichoptera	0		0	9	0
	Chironomidae	0		2	8	16
	Coleoptera	4		2	6	24
	Gastropods	21		0	0	88
	Lamellibranchs	52		2	0	28
	*Other organisms	32		3	14	0
Total for all organisms		109		15	53	216
Wah Stream below Spring	Planarians	0		0	6	0
	Oligochetes	160		32	82	6
	Ephemerida	0		85	270	260
	Trichoptera	0		16	24	251
	Chironomidae	67		191	26	45
	Gastropods	212		1	1	3
	Lamellibranchs	364		31	1	236
	Other organisms	0		37	24	121
Total for all organisms		803		383	434	922
Wah Stream Chabglat Bride	Planarians		69	1		0
	Oligochetes		1	74		9
	Ephemerida		408	67		0
	Trichoptera		207	18		47
	Chironomidae		48	23		5
	Other diptera		25	10		4
	Gastropods		31	19		2
	Lamellibranchs		8	6		50
	Other organisms		118	31		23
			915	249		140

*Organisms other than those listed as key organism.

tonment. The abundance of organisms at this point is unbelievably high because of the enrichment of the stream. Pollution is reflected by the abundance of oligochetes. Otherwise the amount of organic material from Wah Cantonment is only sufficient to enrich the fauna which consists of normal river inhabitants including bivalves.

Samples collected in the small spring show typical fauna found in areas of low productivity. They occur in small numbers and consist primarily of air breathing gastropods and coleoptera. At the mosque below the spring, which is only 100 feet away, the productivity is much larger.

Below the confluence of the Wah stream and the spring outflow, the number of organisms and weight are much reduced below that found at the bridge above. The flow from the springs equals or exceeds that of the river. Reduced productivity of the spring water apparently has a strong influence upon the river where the water enters.

Samples collected at Chablat Bridge, about 3 miles below these points, do not show any increase in productivity. The organisms are all typical varieties as one would expect to find in a river habitat.

The Leh stream as it runs through Rawalpindi, receives a heavy load of pollution and little more than an open sewer as it enters the Soan. Above the city, near the Holy Family Hospital, Zygoptera, Trichoptera, and Mollusca occur in considerable numbers.

These disappear at Dhok Dalalan as pollution increases. Oligochetes and "red" Chironomids predominate at this point. These indicate heavy pollution but not septic conditions.

Numbers can be misleading because of the disparity in size of bottom dwelling organisms. The purpose of the numbers in this case, is to get an idea of the periods of emergence and the seasonal variation of different genera, and to locate the effects of pollution, or the lack of oxygen. They also give some indication upon which to base taxonomic studies and life histories.

PRODUCTION OF THE BOTTOM FAUNA BY WEIGHT

According to Davis, the grade I or rich stream maintain at least 22 g organisms per square meter. Average productivity has standing population weight of 11 to 22 g/per square meter and a poor stream less than 11 g (Table 4).

The high-gradient portion of the streams with their violent runoff and stony, eroded bottoms, fall into the category of the low production areas. These stations showed a lower weight in March and in the fall of the year, probably reflecting the effects of the seasonal rains in the Soan River near Rawalpindi throughout the year. The weight throughout the year are much more stable than at other sampling stations.

The low gradient portions and the polluted areas show relatively high production, but are influenced by other factors. Except for the August samples from the Korang stream at Lethrar Road, there is a reduction during the summer. This may be due to a combination of two factors, *i.e.*, emergence and summer rains. There is a decided reduction at Dhok Dalalan in the Leh reflecting the increase in pollution that occurs within the limits of Rawalpindi.

Samples collected in the Wah Stream, where the gradient is moderate, and the bottom which consists of mixed rubble, show high population weight. Here too there is a decided reduction in summer and a greater one in the fall reflecting the effect of the summer rains. Recovery begins to take place in December. The drainage from the Wah Cantonment apparently enriches this section of the stream. There is a lower production below the flow from the springs and a still lower production at Chablat bridge further downstream. This may reflect recovery from the effects of pollution at Wah. The samples from the Wah stream and the high gradient stations show a productivity that is high as compared with similar type areas in European and American streams.

The specific identifications serve no useful purpose in this particular study. However, a list of organisms is useful for information on the occurrences and distribution of different organisms, and their utilization by fishes. They also tell something of the character of the habitat at each location, including the effect of run off, presence of pollution, and other ecological conditions. Identifications were made simply as to classes, families, or genera as they were known to us. Otherwise they were grouped as Diptera, etc.

LIST OF ORGANISMS FOUND

Porifera; Hydra sp; Planaria; Nematoda; Oligchaeta: *Limnodrilus*, *Chaetegaster*, *Tubifex*, *Nais*, *Ophidonais*; Cheatopoda; Hirudinae; Cladocera: *Daphnia*; Copepoda: *Cyclops*, *Diaptomus*; Ostracoda: *Cyproidea*; Ascellus; Palaemon dayanus, lamerii, malcomsonii; Hydracarina; Ephemerida: *Caenis*, *Baetis*, *Clocon*, *Choroterpes*, *Ephemera* and *Ecdyonururs* Odonata: *Anisoptera*, *Zygoptera*; Hemiptera: *Corixidae*, *Notonectidae*, *Gerridae*; Trichoptera—*Philopotomidae* and at least 3 other species; Lepidoptera larvae; *Diptera*: *Chaoborus*, *Culicidae*, *Tipulidae* adults, unknown pupae, *Chironomidae*, *Chironomous*, *Tanypus*, *Tanytarsus*, *Ceratopogoninae*, *Tabanidae*, *Simulidae*, *Dixa sphedon* and unidentified adults; Coleoptera: *Hydrous*, *Berosus*, *Psephenidae*, *Halipidae*, *Hydroporus*, *Dytiscus*, etc. Mollusca: Gastropoda: *Physa*, *Gonobiosus*, *Planorbis*, *Pleurocercus*, etc.,

Pelecypoda—2 or 3 genera of Sphearidae; Numerous land insects and spiders; Fish eggs and embryos.

Fifteen species of fishes were examined for the determination of the utilization of food organisms collected from the bottom samples in the general area. Out of the fifteen examined nine contained some bottom organisms. Six of these were primarily carnivorous. Eight species fed primarily on bottom debris and algae. These collected a large variety of diatoms, filamentous algae, debris, and clay silt.

TABLE 4.—WEIGHT OF ORGANISMS IN GRAM PER SQUARE METER. HIGH GRADIENT AREAS.

Location	Feb. Mar	April	May June July	Aug. Sept.	Dec.
Salgram-Korang	8.3575	—	—	—	—
Chattar Bridge	3.3904	—	1.9648	—	—
Korang-16 miles	2.0340	5.0766	2.8084	9.1214	7.2388
Soan above Leh	0.3260	1.6872	1.6340	0.3789	2.9597
Soan below Leh	1.2807	20.6162	19.1824	—	17.6314
Average weight of organisms	3.0737	9.1266	6.3974	4.7501	9.2766

LOW GRADIENT

Nurpur-Korang Br.	32.0382	25.3301	—	4.2195	10.0191
Below Rawal Dam	50.1003	—	—	1.1219	51.4648
Gumrah Stream Lethrar Rd.	—	5.2636	2.0451	0.1658	3.5564
Korang-Stream Lethrar Rd.	—	166.9712	4.4778	105.4011	3.5564
Saidpur-Leh	2.4838	65.8219	57.4044	1.1948	17.6507
Average weight of organisms	28.2074	65.8467	21.3091	22.4206	19.2494

POLLUTED—LOW GRADIENT

Leh Stream Holy Family	—	9.2786	16.6411	2.8525	17.5507
Dhok Dalalan	—	3.9590	1.0549	—	3.5048
Average weight of organisms	--	6.6188	8.848	2.8525	10.5277

MODERATE GRADIENT—WAH DRAINAGE

Small spring	7.1473	—	1.2874	1.9268	7.6930
Near Mosque	—	—	34.0067	—	2.4757
Below Large spring	24.4051	—	1.1948	2.6264	2.6918
Above Springs	633.5045	—	54.5088	12.6830	258.8516
Below springs	27.4061	—	62.8402	12.7123	25.2933
Chablat Bridge	—	—	35.9644	—	16.6681
Springs average	15.7762	—	12.1696	2.2766	4.2863
Wah stream average	330.4503		51.1067	12.6976	100.2710

TABLE 5.—FOOD PREFERENCES OF FISHES COLLECTED.

Barilius vagra (Lahori)	Diptera pupae	34%
	Ephimerida	29%
	Trichoptera	27%
Based upon	Chironomidae	21%
	Ceratopogoninae	9%
90 specimens	Coleoptera	8%
	Zygoptera	2%
Barbus (Tor) putitora (Mahseer)	Ephemerida	44%
	Chironomidae	44%
35 specimens	Empty	17%
	Ulothrix	11%
	Gastropoda	9%
	Trichoptera	6%
	Diptera pupa	6%
Barbus (Puntius) ticto (Pandra)	Spirogyra	33%
	Ephemerida	23%
	Trichoptera	1%
	Ostracoda	5%
	Copepoda	5%
	Diptera Pupa	5%
Labeo boga	Diptera pupa	49%
	Filamentous algae	26%
	Diatoms	21%
	Ephemerida	17%

TABLE 6.—FOOD PREFERENCES OF FISHES COLLECTED.

Chela sp. (Bounchee)	Epithema	46%
	Navicula	46%
	Empty stomachs	43%
35 Specimens	Surierlla	40%
	Cosmarium	34%
	Fragillaria	34%
	Merismopedia	29%
	Coccochloris	26%
	Diatom	26%
Garra Jerdoni 90 specimens	Diatoma	50%
	Navicula	31%
	Eithema	24%
	Spirogyra	22%
	Closterium	21%
	Oscillatoria	15%
	Surirella	15%
	Amphora	11%
	Cosmarium	10%
	Rivularia	10%
Barbus (Puntius) sophore (CHIDU)	Diatoma	65%
	Navicula	60%
48 specimens	Epithema	37%
	Spirogyra	20%
	Chironomidae	5%

For the purposes of this study only the more abundant species of fishes will be considered since they make up the entire picture of the food utilized, since the fish of a single species from all habitats were lumped together, the food preferences are readily apparent. These tables are based upon the percentage of all of the one species examined that contained a single food item. The frequency of selection by the fish indicates food preference. If the frequency of occurrence in the gut is compared with its abundance in the habitat where the fish is collected its importance can be estimated. Foods occurring with lesser frequency were left out, but the data are available in our analyses.

Labeo boga seems to be omnivorous. Two preferences are diptera pupae in 49 percent of the guts, ephemerida in 17 percent; filamentous algae, 26 percent, and diatoms 21 percent. Diptera pupae do not occur in the sampling in any number. Since they are preferred, it shows that the fish exercises a great deal of selectivity in the choice of food.

Barilius vagra showed considerable selection in that the diptera pupae occurred in 34 percent of the specimens examined. However, the abundant varieties of larvae also were utilized the most, since they occurred in almost all specimens in some numbers.

Garra jerdoni, *Barbus (Puntius) ticto*, and *Chela sp.*, fed upon bottom debris with its attendant population of diatoms and silt. However, *B. (Puntius) sophore* which had diatoms and algae in all specimens, contained filamentous algae in 72 percent, and some animal food in 39 percent. This would seem to indicate that some attempt was made to utilize animal food.

Barbus (Tor) putitora and *B. (Puntius) ticto* primarily utilized bottom organisms as food. But in each case some filamentous algae was found. This indicated that it was taken in conjunction with feeding upon the desirable organisms. Seventeen percent of the stomachs of *B. (Tor) putitora* were empty.

Discussion

Within the aquatic habitat there are several levels of food utilization. The most basic are the "grazers" or those utilizing organic debris and associated algae. The gazers may be insect larvae such as trichoptera or ephemeroptera, or they may be fishes. Organic debris and associated algae is the largest source of food; hence the weight of fishes using them as food is the greatest. The grazing species are the most abundant fishes in all the habitats studies. It shows an efficient utilization of the available food resources. This is a good basis for large fish production.

While some of these fishes are large, and are commercially valuable, such as *Lebeo rohita* and *L. boga*, the more abundant varieties, such as *Garra jerdoni Chela sp.*, and *Barbus* (*Puntius*) *sophore* are small and are of no commercial value.

At the second level aquatic insect larvae are the "grazers" and are eaten by carnivorous fishes. The weight of fish that can be supported at this level is smaller than at the previous level, but is still very large in total weight. The number of species collected that utilize insects as food is about equal to the number using debris. Most of the piscivorous species also feed upon insect larvae when they are of smaller size. In this group of fishes *Barbus* (*Tor*) *putitora* is of large size and commercially valuable. The majority of species and the most abundant ones in the habitat are small and of little commercial value.

The third level, or piscivorous varieties of fish are almost entirely lacking in the samples collected. In a normally balanced population these are among the larger and less abundant varieties, but usually valuable commercially. The total weight produced per unit area is very much less than the other two types of feeders. They have the important function of keeping the populations in balance, and converting many small species into larger carnivorous fish which have more value. Their presence in the habitat insures the most efficient utilization of the available food and space in the habitat. There is vast space and food that cannot be converted to human food if there is an abundance of smaller species of no value. They would be converted to human food if a sufficient number of piscivorous species are present to keep the population in balance.

We have found fish in the stomachs of some of the catfishes. These species are limited in number and range so they do not use the smaller fishes efficiently. From what we have seen of the fishes in this study, it would seem that a species of piscivorous fish need to be stocked which can range over all of the habitats in the stream and utilize the smaller species more efficiently. It is a well known fisheries management principle that plans must be concerned with the structure of the population. To make the most efficient use of available fish food and to convert non-marketable fish to human food, there must be some varieties which will utilize these food sources and be large enough to be attractive to the fisherman.

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