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OBSERVATIONS ON THE POPULATION ECOLOGY OF AQUATIC INSECTS IN TWO COLDWATER KUMAON LAKES WITH REFERENCE TO ABIOTIC FACTORS

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Introduction

The occurrence and abundance of a species or a group of insects is dependent on the complex interactions of ecological factors. Unfortunately, meagre information is available on the population ecology of Indian aquatic insects. Tonapi (1959) is probably the first who contributed a note on the population ecology of aquatic bugs of Poona. Other contributions on this aspect of ecology are mainly by Michael (1968), Julka (1973, 1977), Tonapi and Ozarkar (1970), Raghunatha Rao (1978), Bose and Sen (1978).

Although some recent papers on the ecology of aquatic insects of Kumaon are in literature (Bisht, 1979 ; Bisht and Das, 1979a, 1979b, 1979c, 1979d, 1979e, 1980a, 1980b, 1982a, 1982b ; Das and Bisht, 1979), there is no comprehensive report on the population ecology of these insects so far as the high altitude Kumaon lakes are concerned. Due to this paucity of knowledge and the significance of aquatic insects especially in fish and fisheries, the study of population ecology have been incorporated in the present paper.

Materials and Methods

Five stations were established around the lake, Nainital and Bhimtal for quantitative estimations of different groups of aquatic insects. These were surveyed fortnightly and standard hauls made of about 5 meters to and fro by a pole hand net of conventional design (30 cm in diameter), using organdie cloth of about 40 mesh. A container having a capacity of one litre was held in position at the end of the net. Standard net sweeps were made for a two year period (1977-1979). The speed of the sweeps was kept reasonably constant. For surface dwelling, macrophytic and substratal insects the net was operated separately in the respective supporting areas. In laboratory the samples

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were throughly washed with the help of a seive of 40 mesh for further study. Seasonal fluctuations in population of diffarent insect orders was determined by calculating monthly average values of each haul at five stations in each lake.

Result and Discussion

The annual percentage composition of the insect orders, Ephemeroptera, Odonata, Hemiptera, Coleoptera, Trichoptara and Diptara during 1977-78 and 1978-79 was observed to differ radically in the two lakes, Nainital (eutrophic and polluted) and Bhimtal (oligotrophic) (Table 1, figs 1-4). In Nainital the order Diptera showed a marked predominance with an annual percentage composition of 54.6 and 59.4 during the first and second years respectively. Case-building red *Chironomus* and *Simulium* larvae were the principal components of this order. Coleoptera, Trichoptera, Hemiptera, Odonata and Ephemeroptera were the next in a descending order of predominance (Table 1). On the other hand in lake Bhimtal, Coleoptaera constituted the major part of the population spectrum with annual percentage composition 34.5 and 35.9 during the first and second years respectively. Next in order of abundance, Hemiptera, Diptera, Odonata, Ephemeroptera and Trichoptera were found to be present in that order (Table 1).

The data on the seasonal fluctuations in population of different orders of aquatic insects in lake Nainital and Bhimtal during the two years study have been presented in figures 5 to 8.

TABLE 1. Percentage composition of different orders of aquatic insects.

Order	Annual percentage composition				
	Nainital			Bhimtal	
	1977-78	1978-79		1977-78	1978-79
Diptera	54.6	59.4	Coleoptera	34.5	35.9
Coleoptera	26.4	25.0	Hemiptera	21.8	21.1
Trichoptera	9.8	7.6	Diptera	19.5	19.6
Hemiptera	5.5	4.6	Odonata	11.2	10.5
Odonata	2.8	2.7	Ephemeroptera	9.1	7.5
Ephemeroptera	0.9	0.7	Trichoptera	3.9	5.4

Some of the interesting features in terms of abiotic and biotic factors that governed the potentiality and seasonal fluctuations in population of aquatic insects of the two Kumaon lakes are : 1. *Texture*

of lake substratum : The nature of lake substratum has a direct influence on the population of aquatic insects (Bisht and Das, 1980b), and is very true for saxicoline and detrital community of aquatic insects. It may determine the potentiality of a species or a group in a given environment. This potentiality was shown by the fluctuations in population, as is evident in some dominant forms of aquatic insects such as *Chironomus*, *Simulium* (Diptera) and *Hyphoporus aper* (Coleoptera) of lake Nainital and *Micronecta* spp., *Heleocoris vicinus* (Hemiptera) ; *Sternolophus rufipes*, *Helochares crenatus* (Coleoptera) of lake Bhimtal.

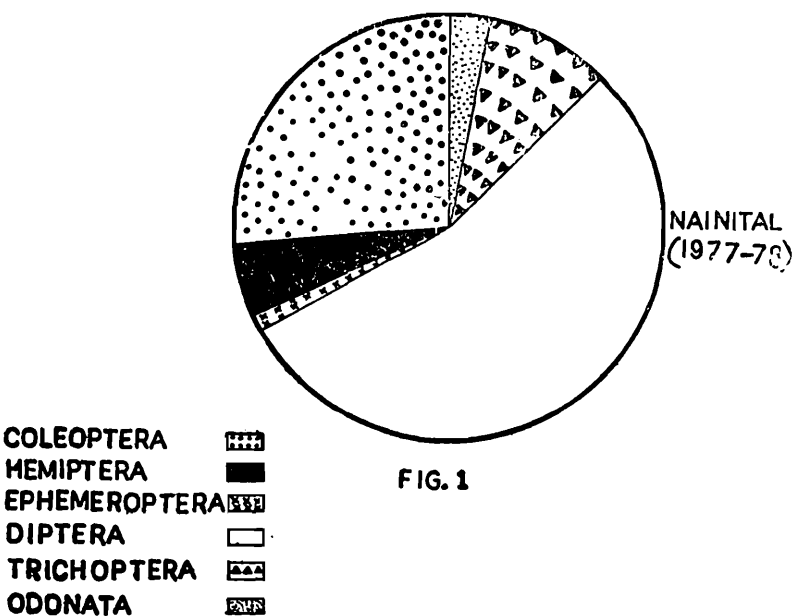

FIG. 1

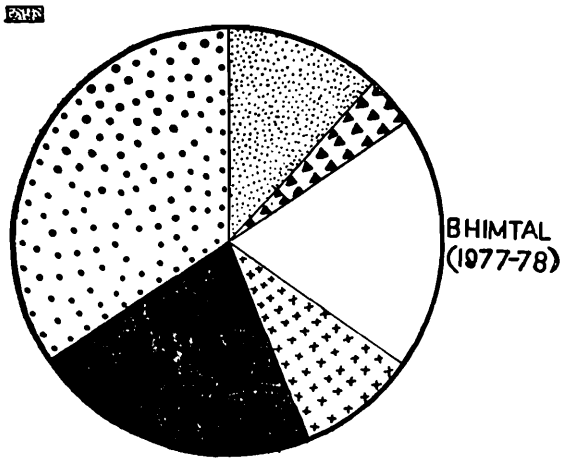

FIG. 2

Observations (figs 1-4) reveal that out of six orders of aquatic insects in lake Nainital the order Diptera (predominated by *Chironomus* and *Simulium*) showed a marked predominance over all the other groups. This is attributed to the muddy and detrital bottom of lake Nainital, a favourable abiotic for high Chironomid population. On the other hand, lake Bhimtal which has a sandy, rocky or mixed type of substratum with small amount of detritus at some places, aiso reveals that the population of case building chironomids is low due to lack of sufficient suitable substratum. These observations are in support of

the view of Wene (1940), Curry (1962), Oliver (1971) and Forsyth and Fox (1976), who stated that the sand is not a preferred substrate for the web-spinning and case-building chironomids.

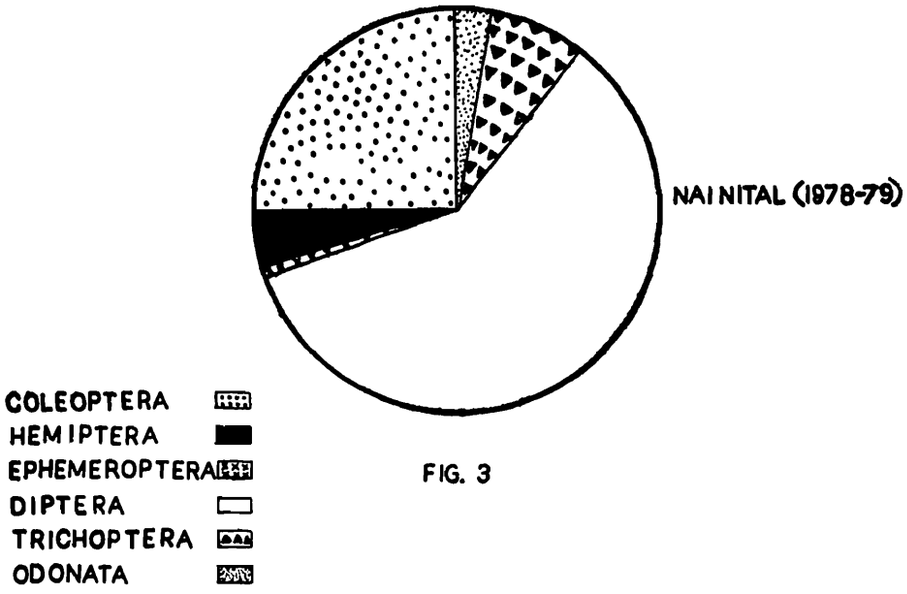

FIG. 3

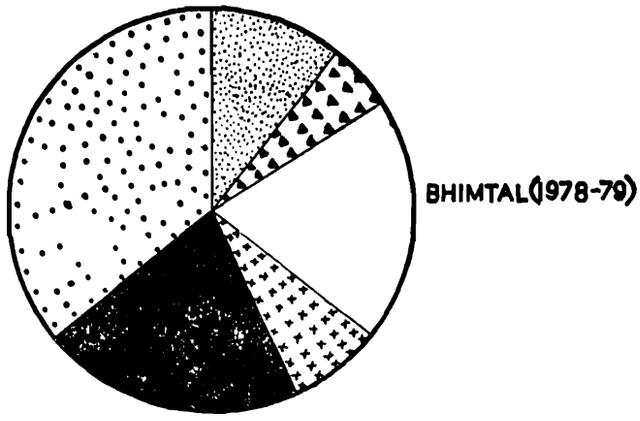

FIG-4

The presence of saxicoline community of aquatic insects such as *Micronecta merope*, *Heleocoris vicinus* (Hemiptera) and *Caenis*, *Leptophlebia*, *Ephemera* (Ephemeroptera) in lake Bhimtal and their absence in lake Nainital (Bisht and Das, 1980b), is another evidence to show the affect of lake substratum on the qualitative and quantitative distribution of aquatic insects. Moreover, in general it was also observed that most of the species show considerable numerical variations at different stations in the lakes due to fluctuations dependent upon the nature of lake substratum.

2. *Quality of water and pollution* : The quality of water appears to be an important factor in determing the qualitative and quantitative variations in lacustrine insects of Kumaon. The physico-chemical features such as high turbidity, Co_2, (specially during winter), methyl orange alkalinity and total hardness and low dissolved oxygen have clearly shown that lake Naintal is eutrophic and highly polluted (Das,

1978 ; Das and Bisht, 1979). Observations in this lake reveal that the species composition (Bisht and Das, 1983) and the population of different groups of aquatic insects in general and Ephemeroptera (smallest portion of spectrum ; figs 1 and 3) in particular, is greatly reduced by eutrophication and organic pollution. These observations are in close agreement with Clark et. al. (1967) that pollution and anoxia are quite common causes of death specially those which respire through gills, such as ephemeropterans in the present study. On the contrary, lake Bhimtal which is oligotrophic shows diversified and higher populations of aquatic insects than lake Nainital.

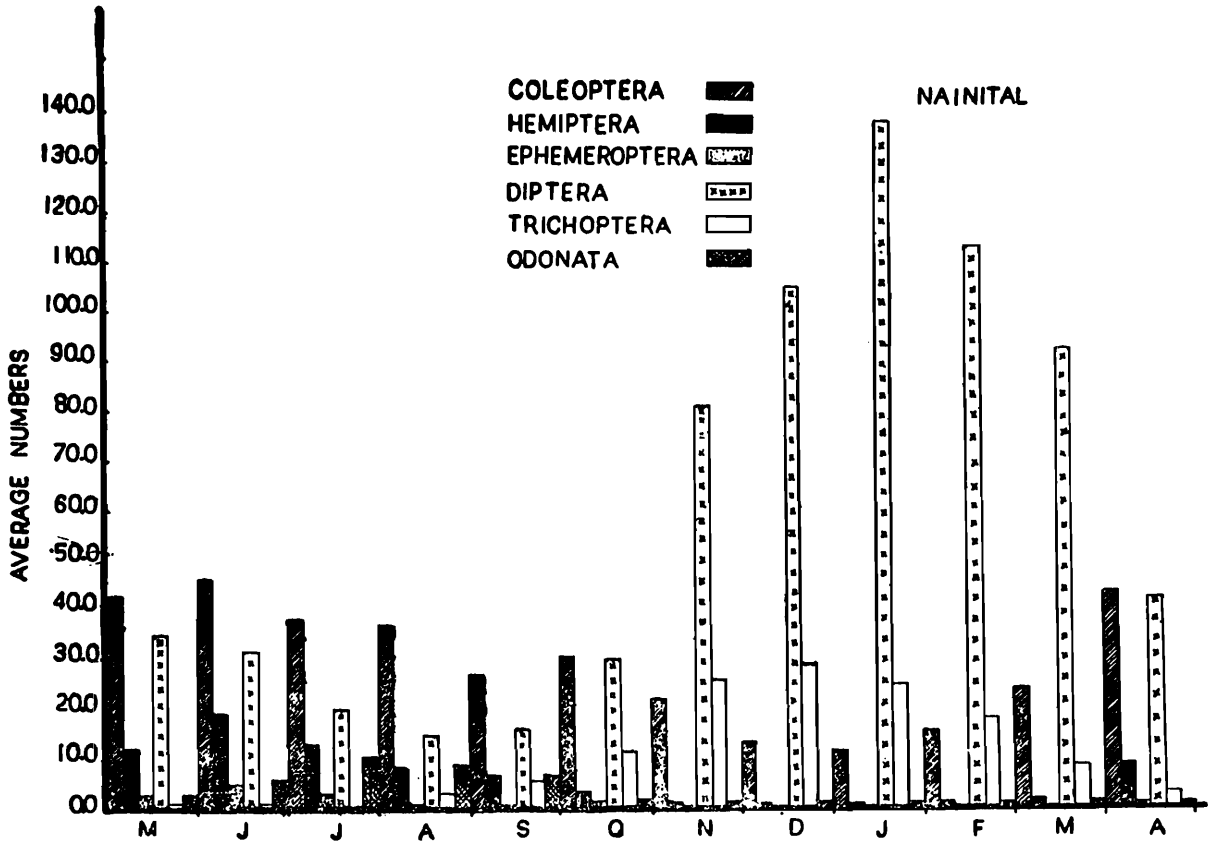

FIG. 5

The chironomids which can live at low concentrations of oxygen for a considerable time (Macan, 1963), oxygen does not appear to have any adverse effect on their population. Moreover, the largest portion of the spectrum of Diptera (Table 1 ; figs. 1 and 3) predominated by chironomids (*Chironomus, Simulium*) and their high population in lake Nainital during winter months (figs 5 and 7) (with average DO-4.3-9.7 ppm ; Methyl orange alkalinity, 113.0-240. 0 ppm ; total hardness 289.6-396.2 ppm ; Co_2 5.85-22.0 ppm and Turbidity 90.0-116 5 ppm ; with lake colour dirty green to brown green) shows them to be resistant to pollution. Therefore, these insects have been considered as the biological indicators of pollution (Das, 1978 ; Bisht and Das, 1980b) along with other insects (e. g. *Hyphoporus aper*, Bisht and Das,

1979c). Observations on physicochemical parameters on aquatic insects have also revealed that the range of these parameters varies from species to species (Das and Bisht, 1979 ; Bisht and Das, 1983) which in its turn affects the distribution and the abundance of a species.

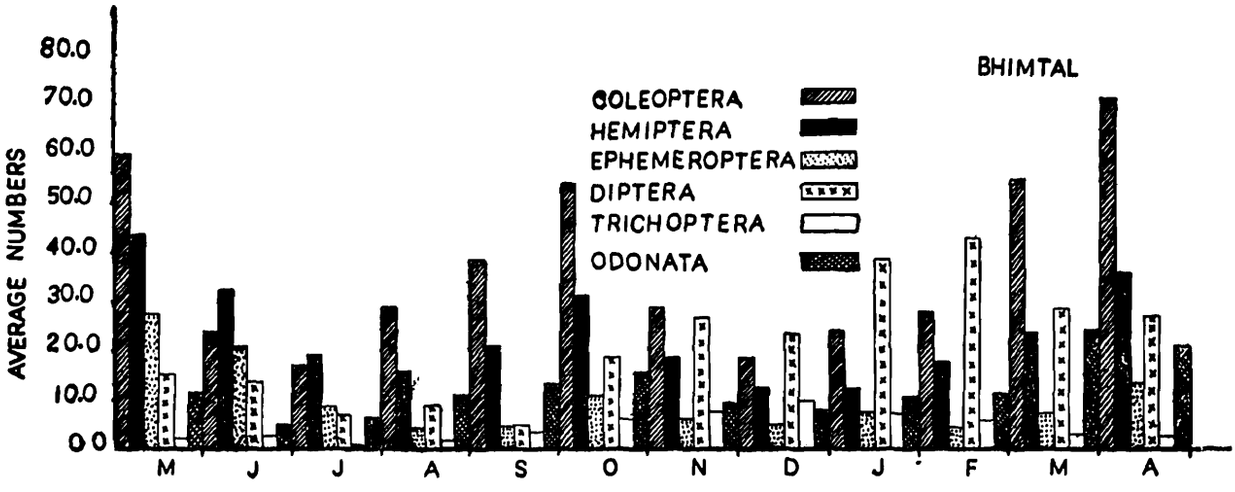

FIG. 6

3. *Fluctuation in water level* : Fluctuations in water level due to rains, drinking water supply from the lakes and natural process of evaporation are common features of Kumaon lakes. Moreover, in lake Bhimtal as the sluice gate is opened for irregation purposed during the late summer, there is a sudden fall in water level (5 to 7 meters), which in turn adversely affects the population of aquatic insects. During rains the water level rose up in the lakes, which have an adverse effect on the population abundance of insects, especially those which pass most of their lives at the shallow bottom such as Diptera, Ephemeroptera in the present study (Figs 5 to 8). This is not only due to water level but also due to silting during the rains.

4. *Quality and qnantity of hydrophytes* : It has been well established that quality and quantity of aquatic vegetation greatly affects the biological potential of aquatic insects. Poor quality and quantity of hydrophytes results a poor entomofauna and vice versa (Bisht and Das, 1980b). Population studies (figs 5 to 8) also reveal that all the insect orders except the case—building Diptera and Trichoptera were present with higher numbers in lake Bhimtal (with rich quality and abundant hydrophytes). Macan (1963) also recorded that in big lakes the scarcity of emerged vegetation presumably act as a deterrent.

5. *Temperature variations of air and water and light* : Temperature seem to be the most important ecological factor governing the population of aquatic insects in Kumaon lakes. Being at a higher altitude

(1220-1938 m asl) the Kumaon lakes have a lower air and water temperatures than in the plains of India. Aquatic insects such as most of the bugs and beetles hibernate during winter (November to February), overwinter as adults and during this period the resultant population is in a declining stage. This is very true for insects in lake Nainital. On the approach of spring (March) due to increase in temperature the metabolic activities of these insects are increased, the gonads are activated and breeding takes place, which in turn give rise to new generations with resultant higher population.

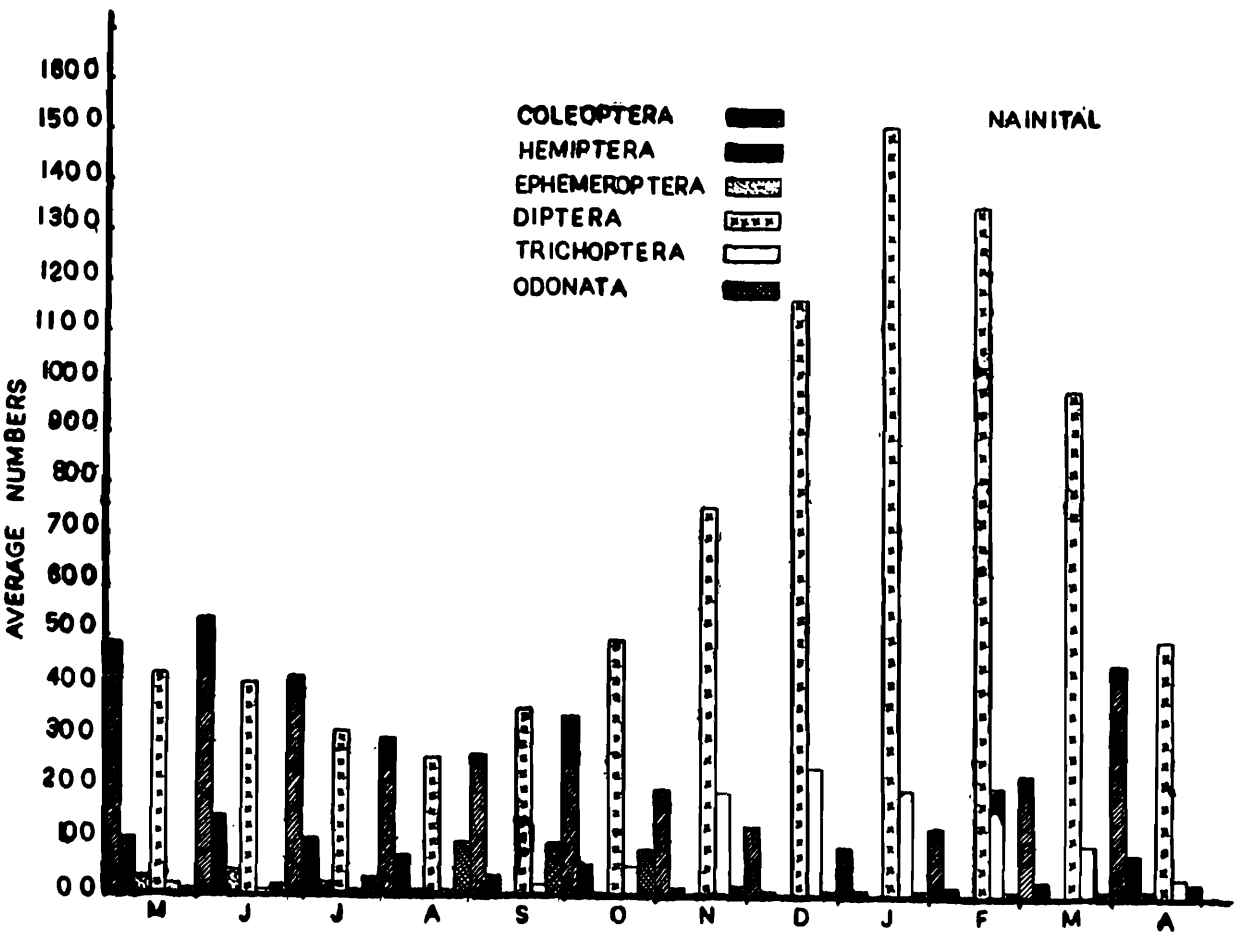

FIG. 7

Population fluctuation studies in lake Nainital and Bhimtal have reavealed that the population of aquatic insects except Diptera and Trichoptera remain maximum during summer (figs 5 to 8) (with higher air and water temperatures and more sunlight) ; while it was lowest during winter months (with lower values of air and water temperatures and less amount of sunlight). It is significant to note that aquatic *H*emiptera and Coleoptera of this region remain abundant during March to June (summer) (Das and Bisht, 1979). However, in the plains of India the hemipterans remain most abundant from July to March (Tonapi et al 1970).

6. *Season of emergence of preimaginal forms of aquatic insect* : The population of some Diptera (*Chironomus*, *Simulium*) and trichopteran larvae in Kumaon lakes decreases due to the emergence of adults mainly during early summer as a result of increase in temperature. Similarly ephemeropterans (*Leptoplebia*, *Caenis*, *Baetis*, *Cloeon* and *Ephemera*) have been observed by the authors to emerge mainly during the summer, with corresponding decline in the population. These observations are in close agreement with Mani (1957) who noticed the Ephemeroptera, Trichoptera and Diptera at extreme high altitude (3600 m asl) remain as larvae whole year and emerge as adults during the sunny summer afternoons in the succeeding year.

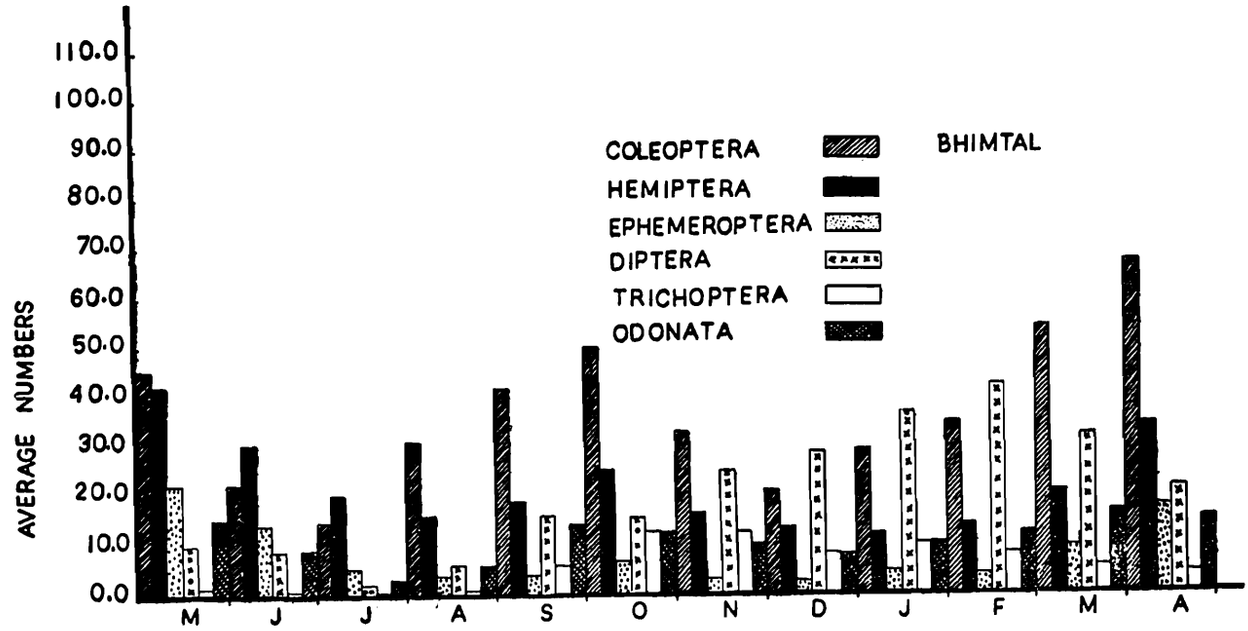

FIG. 8

7. *Capacity of flight in aquatic Hemiptera and Coleoptera* : Fight is rather an uncommon phenomenon for Kumaon aquatic bugs and beetles. It was observed to occur in some aquatic bugs (viz. *Micronecta fulva*, *M. wui*, *M. siva*) and beetles (viz. *Rhantus*, *Agabus*, *Cybister*, *Eretes*, *Berosus*, *Sternolophus*, *Hydrophilus*, *Laccobius*, *Helochares* and *Regimbartia*) of Kumaon lakes, but only during the summer months (May-June), when the temperature of both air and water are high. Due to infrequent flight in these insects, they donot have much significance in migration, colonization and population fluctuations. This is in contrast to the plains of India where aquatic insects are known to be regular fleers and continuously move from one water body to another, since Tagore et al (1974) collected aquatic bugs and beetles at light in Madurai area even during winter months at mid night in appreciable quality and quantity. Flight and its significance in colonization and population of aquatic insects of Indian plains has

also been observed by Tonapi et al (1970), Julka (1977), Bose and Sen (1978). Thus it is evident that flight is probably associated with higher temperatures which prevails in this part of the country only during summer.

8. *Other features* : In addition to the abovementioned factors, the slopes of the lake bottom and least disturbance of the water was observed to favour the abundance of aquatic insects in Kumaon lakes. It is noteble that rainfall doesnot appear to have any significant effect on the period of maximum abundance of aquatic bugs in Kumaon. These results are in contrast to the conditions prevailing in the Indian plains, where rainfall has an augmentative effect on the fluctuations in population of aquatic bugs (Tonapi, 1959 ; Julka, 1977).

Of the biotic factors the predatory action of fishes and other biota upon nymphs/larvae and adults of aquatic insects (Bisht and Das, 1979b, 1979d, 1980a) may also cause a decline in population of insects.

SUMMARY

(1) The annual percentage compositions of aquatic Ephemeroptera, Odonata, Hemiptera, Coleoptera, Trichoptera and Diptera were found to differ radically in the two Kumaon lakes (1220-1938 m asl) ; Nainital (eutrophic and polluted) and Bhimtal (oligotrophic). Data gathered during the years 1977-78 and 1978-79 from these lakes has revealed that Diptera and Coleoptera respectively show a marked predominance over other insect orders. The predominance of Diptera in lake Nainital (due to abundance of *Chironomus* and *Simulium* larvae) has been found to occur mainly due to muddy and detrital texture of lake bottom.

(2) Except the biological indicators of pollution (Das, 1978 ; Bisht & Das, 1979c), the qualitative and quantitative expression of aquatic insects in general and the ephemeropterans in particular has been found to deter by high turbidity, CO_2, Methyl orange alkalinity, total hardness and low dissolved O_2 and pollutents.

(3) Fluctuations in water level also affects the population ecology of aquatic entomofauna in Kumaon lakes.

(4) Poor quality and quantity of hydrophytes has resulted in poor entomofauna ; while their rich quality and quantity has resulted in rich entomofauna, both qualitatively and quantitatively.

(5) Temperature as an ecological factor has been shown to be responsible for the abundance of aquatic entomofauna in Kumaon. Being at a higher altitude than the Indian plains the maximum abundance of bugs and beetles was found during summer (March to June)

rather than July to September for bugs (Tonapi, 1959; Julka, 1977) and July to March for beetles (Tonapi et al, 1970).

(6) Certain other ecological factors, such as emergence of preimaginal forms of Ephemeroptera. Trichoptera, and Diptera; capacity of flight in bugs and beetles and its significance and some physical and biotic factors affecting the population of aquatic entomofauna in Kumaon lakes are also discussed.

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