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Research Article

THE INFLUENCE OF pH AND SALINITY ON THE DISTRIBUTION OF HYDRADEPHAGAN BEETLES

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ABSTRACT

This study attempts to establish the Macroinvertebrate communities of adult hydradephagan beetles were collected from 100 water bodies of Kancheepuram Lake District. The distribution of forty five species of Adephagan beetles has been related to acidity (pH) and salinity (‰) by use of the Index of Representation (I.R.). Distribution and abundance of hydradephagan beetles may probably be dependent upon water pH which is 5.6 and above, they also show significant preferences or aversion to the various classes of salinity.

Keywords: Dytiscidae, Noteridae, Gyrinidae, Haliplidae, Acidity, Salinity, Distribution.

INTRODUCTION

Distribution was studied to document which species occur in the various ponds of Kancheepuram region and in order to characterize the regional species pool of the beetle faunas of protected and exposed sites.

Hydradephagan beetles are one of the most successful groups of insects, distinguished by their adaptive nature in diverse ecological and geographical ranges. Water beetles form an important component of food web in a freshwater ecosystem which is economically important as some of them form natural food for aquatic vertebrates and others as predators on other insects. Literature pertaining to the relationship between the water parameters, availability of food, seasonal variation, competition or predation, aquatic vegetation and migration of dytiscid beetles in freshwater bodies is rather very scanty.

Baid (1959) studied the fluctuations in the salinity of water in Sambhar Lake. The salinity may vary within wide limits from 0.93‰ to 16‰ and found out that seasonal variation in salinity plays an important role in diversity and abundance of aquatic beetle *Laccophilus* during rainy and post-rainy seasons. Sutcliffe (1961) studied the salinity fluctuations in salt marsh with special reference to aquatic insects in which some dytiscid beetle can tolerate salinities ranging from 18-20‰. Clark (1962) provided information on the dispersal activity of insects from natural populations.

Schaeflein (1971) has categorized some *Hydroporus* species as tyrphobiont, tyrphophilous and acidophilous based on the distribution in relation to chemical nature of water. Survey of aquatic invertebrate fauna often shows that water bodies with different pH have distinct assemblages (Sutcliffe and Carrick, 1973). Hebauer (1974) found that the ecological data concerning relationship between species and habitat with reference to acidity (acidophilous) or chlorinity (haloxenous, halophilous and halobiont). Belk and Cole (1975) stated that temporary desert fauna is likely to be characterized by the rapid development, flexibility in food choice, wide tolerance for variations in temperature, water chemistry and powerful dispersal ability. Hildrew and Townsend (1976) determined the abundance and distribution of two species *Plectronemia conspera* and *Sialis fuliginasa* using the Index of Representation (I.R.).

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Tomkiewicz and Dunson (1977) observed changes in pH within a single body of water as a result of acid pollution or human induced changes, which produced temporal or spatial difference in invertebrate population and assemblage structure.

Cuppen (1986) worked on the influence of acidity and chlorinity on the distribution of 18 species of *Hydroporus* from 732 localities in Netherlands by using Index of Representation (I.R.). Patterson and Atmar (1986) observed dytiscids and culicids that may reflect the presence of hierarchical set of ecological relationship among the species and such relationship may be very important for their local distribution patterns. Bendell and McNicol (1987) observed that fish-less lakes were found to have a greater abundance and richness of insects than lakes with fish. Irrespective of pH, fishless lakes supported a similar aquatic insect assemblage which is characterized by an abundance of nekton.

Bendell (1988) examined the relationship between the abundance of *Rheumatobates rileyi* with lake acidity and any other concomitant relationship of the presence of fish. A highly significant positive relationship was found between densities of *R. rileyi* and lake pH, but no relationship was found with the presence or absence of fish.

Introduction of liming and trout may cause decline of species richness and in the population density of *Hydroporus palustris,* (Foster, 1991). Eyre *et al.* (1992) found a relationship to the concept of seasonality and to the environmental stresses affecting the distribution of species. Malmqvist *et al.* (1993) found out that pool size, algae, pH and temperature were factors that influence species richness positively in streams by using the partial least square regression analysis. Blackburn *et al.* (1993) reported the local assemblages of larger species which tend to be less abundant than smaller species, although the correlation between size and abundance is normally low.

Wei Yulian *et al.* (2002) reported that the degree of water humus and altitude are the major factors affecting the beetle distribution and the influence of some environmental factors.

MATERIALS AND METHODS

Hydradephagan beetles of the families Dytiscidae, Gyrinidae and Haliplidae were collected from ponds and lakes located in and around Chennai and Kancheepuram district. The D-frame net (300 mm x 400 mm x 330 mm) with a mesh size of 0.5 mm was used for collections; bottle traps were used and kick samples were also made to collect the large sized beetles.

Water beetles were collected with the help of D-frame net with a mesh-size of 0.5 mm, from June 2004 to June 2006. Each sample was done with 15 sweeps for 1-2 meters from the bank with debris for ¼ of the D-net. The maximum depth sampled was 1 meter. The collected animals were placed in small aquaria. After sieving, the samples were transferred to 70 % ethanol and later sorted in the laboratory. For taxonomic studies the collected water beetles were preserved in 70% ethanol. The preserved specimens were observed with Labomed Zoom Stereo trinocular microscope model Zm 45 TM.

Ecological Studies

Kancheepuram district, Tamilnadu, India (covers an area of 4447.21 sq. km. spread over 1252 villages). The district lies in between 12º, 10′ and 13º 15′ north latitude and 79º 15′ and 80º. 2′ east longitude. It is bound on the North by Thiruvallur district, on the east by Chennai city and Bay of Bengal, on the south by Villupuram district and on the west by Vellore district.

Temperature ranges from 36.6ºC to 21.1ºC; the average annual rain fall in most of the places of the district is around 1200 millimeters. 100 ponds were selected to represent broad ranges. Kancheepuram and its surroundings include a number of water bodies such as swamps, ponds and lakes. 100 water bodies were selected to represent various ranges of biotic and abiotic factors.

pH of the sample was measured using pH meter; salinity was determined by Mohr's method. Water analyses were done within 36 hours after collections were made, the values of pH and salinity was divided into classes as given in the tables. Regional distribution was determined using Spearman's Rank Correlation.

The distribution of hydradephagans was related to pH and salinity using the Index of Representation (I.R), Hildrew and Townsend (1976).

$$I.R = (O-E) / \sqrt{E}$$

Were, O = number of observations of a certain species in a certain class of the factor considered and E = expected number of observations.

The statistical significance was tested by the chi-square test. Calculation of I.R. values is based on the null hypothesis (H_o) that a species has no preference or aversion towards certain classes of the factor considered and is represented in all classes equally. H_o was accepted when the differences between observed and expected number of observations was not sufficient to obtain chi-square values above the 5% level. H_o was rejected when chi-square values were higher than 5%.

When H_o is rejected it indicates under-or over-representation in one or more classes of the considered factor. Positive I.R. values indicate over-representation (preference) and negative values indicate under-representation (aversion). Following Tolkamp (1980), Cuppen (1986) differences in I.R. values are considered to be significant when the values deviate from 2 or more from zero. The Index of Representation has been used instead of frequency distributions because the number of observations in different classes is not equal and can lead to incorrect interpretations (Cuppen, 1983, 1986).

RESULTS

pH

Table 1 gives the observations for water pH classes and distribution of hydradephagan beetles over these classes. These data are useful for the calculations of Index of Representation (I.R.) value. The table shows that *Hydroglyphus flammulatus* is the most commonly collected species of hydradephagan beetles over a wide range of pH classes. *H. flammulatus* is present in almost all the collections. *Dineutus spinosus* occurs in the pH class 7.1 to 7.5 and it is absent in all other pH classes. *Haliplus variegates* is collected only in pH class 8.1 and above. The table shows that *Laccophilus sharpi, L. parvulus* and *L. flexuosus* are present in all the pH classes, particularly they are collected in the sites having a pH between 6.1 and more than 8.1. These species are the most commonly occurring hydradephagan beetles in all the collections during this study.

Table-2 provides the index of representation values of the various hydradephagan beetles with respect to water pH. This table shows that most species collected have significant preferences and/ aversion to certain pH classes. The three species such as *Cybister confuses, Canthydrus luctuosus* and *C. morsbachi* have no significant I.R. values.

Hydaticus fabricii, Hyphydrus flavicans, H. renardi, Hydrovatus sinister, Laccophilus inefficiens, Neohydrocoptus subvittulus, Gyrinus convexiculus and *Haliplus arrowi* are found to be significantly indifferent to various pH classes.

The acidity is one of the factors which influence the species composition in a water body. The deviations of the I.R. value from zero and number of pH classes between significantly positive and significantly negative values show an importance of acidity as an environmental variable. Based on the I.R. values the species can be arranged in a way that they form a list from species mainly living in acid waters to species mainly living in alkaline waters. A few species such as *Eretes griseus, Hydaticus vittatus, Sandracottus dejeani, Hydrovatus confertus, Clypeodytes pederzanii* and *Canthydrus laetabilis* are substantially considered as acidobiont species. The species of *Rhantaticus congestus, Copelatus feae* and *Hydroglyphus pendjabensis* are found in both strong and weak acid water (Table-2). So, they are treated as acidobiont and acidophilous species. They show under representation between pH 5.1 and 6.5 (Table-3).

Cybister convexus, Hydroglyphus flammulatus and *H. milleri* survive mainly in weakly acidic conditions and they are acidophilous. *Hydroglyphus pradhani, Laccophilus sharpi, L. parvulus, L. flexuosus* widely occur in weak acid and weak alkaline pH. They seem to have a wide pH (6.1-8.0) tolerance.

Hydaticus chennaiensis, Cybister tripunctatus, Hydrovatus rufescence, H. subtilis, H. acuminatus, H. vaziranii, Clypeodytes bufo, Yola consanguinea, Hydroglyphus inconstans, Herophydrus musicus, Peschetius quadricastatus, Laccophilus anticatus, Neohydrocoptus bivittis, Dineutus spinosus, D. unidentatus, D. indicus, Orectochilus productus and *Haliplus variegates* probably belong to significantly alkaliphilous category.

Salinity

The I.R. values for the various species in the different ponds with respect to salinity are provided in table-4. It shows that most of the species have significant preferences or aversion to various classes of salinity.

No significant I.R. values have been obtained for *Cybister convexus, C. confusus* and *Copelatus feae. Hydroglyphus milleri* and *Laccophilus flexuosus* show negatively significant values.

It is clear that the negative or positive I.R. values do not deviate much from zero. Significant values most often do not deviate much from 2 and numbers of salinity classes between significantly positive and significantly negative values are large.

Five acidobiont species namely *Eretes griseus, Hydaticus vittatus, Sandracottus dejeani, Clypeodytes pederzanii* and *Canthydrus lactabilis* and none of the acidophilus species are significantly over represented in water very low in salinity, 0.04‰ to 0.09‰ (ppt). Among the alkilophilous species *Cybister tripunctatus, Hydrovatus rufescens, H. vaziranii, Herophydrus musicus, Laccophilus anticatus* and *Neohydrocoptus bivittis* show a significant over representation at higher salinities between 0.16 to 0.22‰ (ppt). Correlation shows all species except a few such as *Hydaticusvittatus, H. fabricii, H. chennaiensis, Cybister convexus, Cybister confuses, Copelatus feae, Hyphydrus renardi, Hydroglyphus milleri, Laccophilus anticatus, Canthydrus morsbachi, Dineutus spinosus, D. unidentatus* and *Haliplus variegates* show a positively significant preference for a salinity range of 0.04-0.06‰ (ppt) (Table - 4).

Table 1. Number of observations for pH-classes and Number of observations of Hydradephagan beetles.

pH	5.1-5.5	5.6-6.0	6.1-6.5	6.6-7.0	7.1-7.5	7.6-8.0	8.1<
pH classes	1	2	3	4	5	6	7
No. of observations	3	3	11	21	26	19	18
Eretes griseus (Fabricius)	2	11	0	25	29	18	12
Hydaticus vittatus (Fabricius)	10	8	13	12	14	22	8
H. fabricii (MacLeay)	7	12	11	20	81	17	8
H. chennaiensis n. sp.	0	0	10	9	27	10	23
Rhantaticus congestus (Klug)	12	10	27	26	24	39	24
Sandracottus dejeani (Aubé)	24	16	0	0	12	0	0
Cybister convexus Sharp	0	0	11	3	0	2	6
C. tripunctatus (Olivier)	1	0	9	8	3	22	8
C. confusus Sharp	1	1	2	2	3	7	8
Copelatus feae Régimbart	21	4	36	18	8	5	31
Hyphydrus flavicans Régimbart	17	12	38	30	20	84	65
H. renardi Severin	4	13	31	44	18	77	50
Hydrovatus rufescens Motschulsky	0	0	8	10	44	3	56
H. subtilis Sharp	12	0	44	60	113	80	93
H. acuminatus Motschulsky	3	0	43	68	155	95	117
H. sinister Sharp	0	0	0	0	2	0	3
H. confertus Sharp	1	0	0	0	4	0	0
H. vaziranii n. sp.	4	0	0	0	0	3	0
Clypeodytes bufo (Sharp)	0	0	0	3	39	8	1
C. pederzanii n. sp.	30	0	0	17	0	17	23
Yola consanguinea (Régimbart)	0	0	0	12	50	7	16
Hydroglyphus pradhani (Vazirani)	0	0	7	27	34	0	13
H. flammulatus (Sharp)	27	7	114	176	185	143	136
H. milleri Madani and Kumar	0	3	3	19	9	7	12
H. inconstans (Régimbart)	3	4	2	35	62	62	50
H. pendjabensis (Guignot)	0	20	33	17	37	37	28
Herophydrus musicus (Klug)	0	0	4	42	78	38	8
Peschetius quadricostatus (Aube)	0	0	0	8	30	2	6
Laccophilus anticatus Sharp	0	0	2	27	59	29	32
L. sharpi (Regimbart)	13	9	81	105	109	130	116
L. parvulus Aube	5	7	98	118	204	125	106
L. flexuosus Aube	7	8	89	97	188	100	131
L. inefficiens (Walker)	2	14	0	12	51	14	6
Neohydrocoptus bivittis Motschulsky	0	0	5	23	19	24	34
N. subvittulus Motschulsky	0	2	33	34	76	67	37
Canthydrus lactabilis (Walker)	6	18	27	58	60	36	40
C. luctuosus Aube	6	12	23	50	71	44	31
C. morsbachi (Wehncke)	0	0	5	22	29	18	7
Dineutus spinosus (Fabricius)	0	0	0	0	12	0	8
D. unidentatus (Aube)	12	0	9	32	42	33	161
D. indicus Aube	0	0	0	0	28	0	6
Gyrinus convexiculus MacLeay	8	6	15	4	33	0	48
Orectochilus productus Regimbart	0	0	0	22	20	0	30
Haliplus arrowi Guignot	0	8	6	0	0	10	14
Haliplus variegatus Sturm	0	0	0	0	0	0	32

Table 2. The I.R. values for the Hydradephagan beetles with respect to pH.

pH	5.1-5.5	5.6-6.0	6.1-6.5	6.6-7.0	7.1-7.5	7.6-8.0	8.1<
pH classes	1	2	3	4	5	6	7
No. of observations	3	3	11	21	26	19	18
Eretes griseus (Fabricius)	-0.53	4.74*	-3.27*	1.03	0.96	-0.10	-1.31
Hydaticus vittatus (Fabricius)	4.57*	3.34*	1.11	-1.47	-1.66	1.35	-1.94
H. fabricii (MacLeay)	1.07	3.38*	-1.49	-2.23*	6.73*	-2.32*	-3.79*
H. chennaiensis n. sp.	-1.54	-1.54	0.44	-1.86	1.63	-1.29	2.33*
Rhantaticus congestus (Klug)	3.24*	2.33*	2.17*	-1.38	-2.59*	1.48	-0.96
Sandracottus dejeani (Aube)	17.97*	11.56*	-2.39*	-3.30*	-0.28	-3.14*	-3.06*
Cybister convexus Sharp	-0.81	-0.81	5.52*	-0.75	-2.35*	-1.07	1.03
C. tripunctatus (Olivier)	-0.43	-1.24	1.43	-0.83	-2.73*	3.95*	-0.39
C. confusus Sharp	0.33	0.33	-0.39	-1.35	-1.22	1.14	1.77
Copelatus feae Regimbart	9.01*	0.16	6.11*	-1.54	-4.10*	-3.80*	1.88
Hyphydrus flavicans Regimbart	3.19*	1.42	1.62	-3.46*	-5.70*	4.71*	2.47*
H. renardi Severin	-1.17	2.21*	0.97	-0.82	-5.36*	4.76*	1.12
Hydrovatus rufescens Motschulsky	-1.91	-1.91	-1.46	-3.06*	2.50*	-4.17*	7.33*
H. subtilis Sharp	-0.02	-3.47*	-0.03	-2.66*	1.25	0.41	2.43*
H. acuminatus Motschulsky	-3.01*	-3.80*	-1.36	-3.28*	3.17*	0.38	3.27*
H. sinister Sharp	-0.39	-0.39	-0.74	-1.02	0.67	-0.97	2.21*
H. confertus Sharp	2.19*	-0.39	-0.74	-1.02	2.46*	-0.97	-0.95
H. vaziranii n. sp.	8.27*	-0.46	-0.88	-1.21	-1.32	1.45	-1.12
Clypeodytes bufo (Sharp)	-1.24	-1.24	-2.37*	-2.36*	7.35*	-0.54	-2.70
C. pederzanii n. sp.	16.95*	-1.62	-3.09*	-0.30	-4.66*	0.12	1.85
Yola consanguinea (Regimbart)	-1.60	-1.60	-3.06*	-1.38	6.24*	-2.28*	0.18
Hydroglyphus pradhani (Vazirani)	-1.56	-1.56	-0.64	2.42*	3.06*	-3.92*	-0.41
H. flammulatus (Sharp)	0.69	-3.42*	2.93*	0.82	-0.85	-0.55	-0.49
H. milleri Madani and Kumar	-1.26	1.12	-1.17	2.36*	-1.17	-0.97	0.80
H. inconstans (Régimbart)	-1.38	-0.99	-4.49*	-1.59	1.02	3.20*	1.72
H. pendjabensis (Guignot)	-2.27*	6.53*	3.24*	-3.18*	-0.91	0.76	-0.53
Herophydrus musicus (Klug)	-2.26*	-2.26*	-3.40*	1.05	5.45*	1.00	-4.09*
Peschetius quadricostatus (Aubé)	-1.17	-1.17	-2.25*	-0.53	5.46*	-2.28*	-0.79
Laccophilus anticatus Sharp	-2.11*	-2.11*	-3.55*	-0.77	3.56*	0.13	1.00
L. sharpi (Regimbart)	-0.95	-1.92	2.42*	-1.22	-2.68*	2.23*	1.46
L. parvulus Aube	-3.34*	-2.89*	2.94*	-1.80	2.97*	-0.09	-1.22
L. flexuosus Aube	-2.69*	-2.46*	2.52*	-2.91*	2.65*	-1.64	1.84
L. inefficiens (Walker)	-0.56	6.40*	-3.30*	-1.93	5.28*	-1.11	-2.80*
Neohydrocoptus bivittis Motschulsky	-1.77	-1.77	-1.93	0.20	-1.42	0.91	3.47*
N. subvittulus Motschulsky	-2.73*	-2.00*	1.07	-2.53*	1.74	2.86*	-1.17
Canthydrus lactabilis (Walker)	-0.50	3.93*	0.01	0.91	-0.16	-1.55	-0.62
C. luctuosus Aube	-0.42	1.83	-0.60	0.03	1.53	-0.15	-1.79
C. morsbachi (Wehncke)	-1.56	-1.56	-1.31	1.21	1.94	0.67	-1.99
Dineutus spinosus (Fabricius)	-0.77	-0.77	-1.48	-2.05*	3.13*	-1.95	2.32*
D. unidentatus (Aube)	1.13	-2.94*	-4.04*	-3.68*	-3.56*	-2.96*	15.11*
D. indicus Aube	-1.01	-1.01	-1.93	-2.67*	6.69*	-2.54*	-0.05
Gyriniculus convexiculus MacLeay	2.48*	1.40	0.69	-4.08*	0.84	-4.65*	6.07*
Orectochilus products Regimbart	-1.47	-1.47	-2.81*	1.77	0.47	-3.70*	4.73*
Haliplus arrowi Guignot	-1.07	6.42*	0.89	-2.82*	-3.08*	1.03	2.74*
Haliplus variegatus Sturm	-0.98	-0.98	-1.88	-2.59*	-2.83*	-2.47*	10.93*

*Significant values.

Table 3. The species were classified the nature of pH with related to I.R. value.

Nature of pH	Species	"Significant" over representation	"Significant" under representation
	Eretes griseus	5.6-6.0	6.1 <
	Hydaticus vittatus	≤ 6.0	not significant
Acidobiont	*Sandracottus dejeani*	≤ 6.0	6.1 <
	Hydrovatus confertus	≤ 5.5	not significant
	Clypeodytes pederzanii	≤ 5.5	6.5 ≤
	Canthydrus lactabilis	5.6-6.0	not significant
	Rhantaticus congestus	≤ 6.5	7.1 ≤
Acidobiont + Acidophilous	*Copelatus feae*	5.1-6.5	7.1 ≤
	Hydroglyphus pendjabensis	5.6-6.5	6.6-7.0, < 5.5
	Cybister convexus	6.1-6.5	7.1 ≤
Acidophilous	*Hydroglyphus flammulatus*	6.1-6.5	≤ 6.0
	Hydroglyphus milleri	6.6-7.0	not significant
	Hydroglyphus pradhani	6.6-7.5	7.6 <
Acidophilous + Alkaliphilous	*Laccophilus sharpi*	6.1-6.5, 7.6-8.0	7.1-7.5
	L. parvulus	6.1-6.5, 7.1-7.5	6.0 <
	L. flexuosus	6.1-6.5, 7.1-7.5	≤ 6.0, 6.6-7.0
	Hydaticus chennaiensis	8.1 ≤	not significant
	Cybister tripunctatus	7.6-8.0	7.1-7.5
	Hydrovatus rufescens	7.1-7.5, 8.1 ≤	6.6-7.0, 7.6-8.0
	Hydrovatus subtilis	8.1 ≤	7.0
	H. acuminatus	7.1-7.5, 8.1 ≤	7.0
	H. vaziranii	8.1 ≤	not significant
	Clypeodytes bufo	7.1-7.5	≤ 7.0, 8.1 ≤
	Yola consanguinea	7.1-7.5	6.1-6.5, 7.6-8.0
Alkaliphilous	*Hydroglyphus inconstans*	7.6-8.0	6.1-6.5
	Herophydrus musicus	7.1-7.5	≤ 6.5, 8.1 ≤
	Peschetius quadricostatus	7.1-7.5	6.1-6.5, 7.6-8.0
	Laccophilus anticatus	7.1-7.5	≤ 6.5
	Neohydrocoptus bivittis	8.1 ≤	not significant
	Dineutus spinosus	7.1-7.5, 8.1 ≤	6.6-7.0
	D. unidentatus	8.1	≤ 8.0
	D. indicus	7.1-7.5	6.6-7.0, 7.6-8.0
	Orectochilus productus	8.1 ≤	≤ 8.0
	Haliplus variegatus	8.1 ≤	≤ 8.0
	Hydaticus fabricii		
	Cybister confusus	not significant	not significant
	Hyphydrus flavicans		
	H. renardi		
	Hydrovatus sinister		
+In different	*Laccophilus inefficiens*		
	Neohydrocoptus subvittulus		
	Canthydrus luctuosus	not significant	not significant
	Canthydrus morsbachi	not significant	not significant
	Gyrinus convexiculus		
	Haliplus arrowi		

Table 4. The I. R. values for the Hydradephagan beetles with respect to Salinity.

Salinity (‰)	0.04 - 0.06	0.07 - 0.09	0.10 - 0.12	0.13 - 0.15	0.16 - 0.18	0.19 - 0.22
Salinity classes	1	2	3	4	5	6
No. of observations	12	27	32	9	14	6
Eretes griseus (Fabricius)	3.91*	2.89*	-1.98	-1.26	-2.06*	-2.41*
Hydaticus vittatus (Fabricius)	-0.14	6.50*	-2.24*	-2.80*	-3.49*	0.34
H. fabricii (MacLeay)	-1.32	0.91	-3.24*	-0.01	1.75	4.79*
H. chennaiensis n. sp.	-1.46	-2.89*	0.74	0.33	3.29*	1.04
Rhantaticus congestus (Klug)	2.62*	6.39*	-5.67*	-0.68	-0.14	-3.12*
Sandracottus dejeani (Aubé)	4.71*	2.66*	-1.63	-2.16*	-2.70*	-1.77
Cybister convexus Sharp	-1.62	1.67	0.36	-1.41	0.52	-1.15
C. tripunctatus (Olivier)	-2.47*	0.87	-0.82	-1.21	4.44*	-1.75
C. confusus Sharp	-0.52	1.78	0.84	-0.79	-1.83	-1.20
Copelatus feae Régimbart	1.36	0.14	0.74	-1.82	-1.26	0.23
Hyphydrus flavicans Régimbart	2.46*	2.33*	-2.96*	0.87	-1.51	-0.36
H. renardi Severin	-1.40	3.25*	-2.28*	1.01	-1.77	1.80
Hydrovatus rufescens Motschulsky	-3.81*	-5.72*	0.85	-0.57	6.09*	6.96*
H. subtilis Sharp	-3.35*	-5.14*	-3.76*	7.95*	8.63*	1.40
H. acuminatus Motschulsky	-3.65*	-3.85*	-1.77	8.77*	5.56*	-1.84
H. sinister Sharp	-0.77	-1.16	-1.26	-0.67	2.75*	3.10*
H. confertus Sharp	-0.77	-0.30	0.32	-0.67	-0.84	3.10*
H. vaziranii n. sp.	-0.92	1.53	-1.50	-0.79	2.04*	-0.65
Clypeodytes bufo (Sharp)	0.76	-2.63*	-2.55*	2.99*	1.82	3.97*
C. pederzani n. sp.	-3.23*	6.50*	-4.71*	5.78*	-2.06*	-2.28*
Yola consanguinea (Régimbart)	-3.19*	-4.79*	6.67*	-0.24	1.19	-2.26*
Hydroglyphus pradhanii (Vazirani)	3.94*	-1.90	0.02	-1.59	-1.29	2.33*
H. flammulatus (Sharp)	2.72*	2.21*	-5.87*	3.81*	-1.17	2.14*
H. milleri Madani and Kumar	1.44	0.45	1.47	-0.35	-2.72*	-1.78
H. inconstans (Régimbart)	2.71*	-2.46*	0.27	2.12*	-0.28	-1.40
H. pendjabensis (Guignot)	5.36*	-2.27*	-2.70*	4.71*	0.60	-3.21*
Herophydrus musicus (Klug)	-4.52*	-0.28	2.39*	-2.38*	4.96*	-3.19*
Peschetius quadricostatus (Aubé)	-2.35*	-1.25	3.46*	-1.05	0.61	-1.66
Laccophilus anticatus Sharp	-1.50	2.43*	12.06*	10.74*	9.68*	3.15*
L. sharpi (Régimbart)	3.83*	-1.95	-1.50	4.68*	-1.56	-1.17
L. parvulus Aubé	5.54*	-1.20	-2.41*	0.69	0.54	-1.39
L. flexuosus Aubé	1.46	-2.04*	-0.10	1.90	-0.41	0.79
L. inefficiens (Walker)	3.52*	-1.50	0.23	0.70	-1.04	-1.62
Neohydrocoptus bivittis Motschulsky	-3.27*	-2.88*	2.31*	0.18	2.69*	1.08
N. subvittulus Motschulsky	-4.73*	-3.56*	1.04	4.14*	2.06*	3.64*
Canthydrus lactabilis (Walker)	2.32*	-0.26	0.86	0.63	-2.61*	-1.49
C. luctuosus Aubé	1.23	-3.12*	-0.79	4.91*	1.53	-1.65
C. morsbachi (Wehncke)	-1.83	-3.61*	1.98	0.63	2.87*	0.52
Dineutus spinosus (Fabricius)	-1.55	-2.32*	5.38*	-1.34	-1.67	-1.10
D. unidentatus (Aubé)	-1.98	-5.32*	11.70*	0.78	-6.36*	-4.16*
D. indicus Aubé	-2.02*	-2.94*	7.43*	-1.70	-2.12*	-1.39
Gyrinus convexiculus MacLeay	0.63	-1.04	3.56*	-3.20*	-0.24	-2.62*
Orectochilus producuts Régimbart	-2.94*	-4.41*	8.95*	-2.55*	-1.29	-2.08*
Haliplus arrowi Guignot	2.55*	1.17	-2.34*	-1.85	2.03*	-1.51
Haliplus variegatus Sturm	-1.96	-2.94*	6.80*	-1.70	-2.12*	-1.39

***** Significant values.

DISCUSSION

pH

Bendell (1988) while studying the lake acidity and the distribution and abundance of water striders has found that the mean pH of lakes in which *Metrobates hesperius* and *Trepobates inermis* occur was significantly higher than the mean pH of lakes from which they were absent and he has also found that there was no evidence to show that the distribution of *Gerris* spp. as related to lake acidity. Several hypothesis can be proposed regarding the distribution and abundance of some species in acid conditions. According to Bendell the absence of fish predators and presence of invertebrate predators has to be ruled out in the case of water striders. But the result of the present studies indicates a condition in contrast to this situation. The alkilophilous species show significant over representation in the alkaline conditions. This perhaps may be due to the absence of predatory fishes and invertebrate predators.

An alternative hypothesis according to Bendell is that the food resources of water striders are reduced at low pH. The presence of some of the adephagan beetles like *Eretes griseus, Hydaticus vittatus, Sandracottus dejeani, Hydrovatus confertus* in low pH such as 5.6-6.5 may be probably due to the presence of suitable predators for these species at a pH below 7, were as the alkilophilous species are able to meet their nutritional demand at alkaline pH. There are also a number of indifferent species in different pH classes.

The observations suggest that the presence of a few species in acid conditions and more number of species which are alkilophilous indicate that the toxicological effect of acidity on the eggs and larvae is not much for acidophilous species and may be more on the alkilophilous species. The present study indicates that the distribution and abundance of hydradephagan beetles may probably be dependent upon water pH which is 5.6 and above.

Juliano (1991) while reporting on the changes in structure and composition of an assemblage of *Hydroporus* species along a pH gradient has observed that the total abundance of adult *Hydroporus* was greatest at the less acidic, i.e. pH 5.6-6.2. However, the present study indicates that adephagans belonging to Hydroporines such as *Peschetius quadricostatus* and *Herophydrus musicus* show a significantly over representation between a pH range of 7.1 and 7.5, this may be due to geographic variation in species. pH preferences complex responses of individual species to many factors in an aquatic environment. According to Juliano (1991) pH is not the only or the even most important factor influencing *Hydroporus* population and assemblage organization. However studies show that pH may perhaps be one among the few important factors that influence the distribution of hydradephagans.

The present observations on the abundance and distribution of Hydradephagan beetles suggest that the alkilophilous species are more common in all water bodies, larger beetles like *Eretes griseus, Rhantaticus congestus, Sandracottus dejeani, Cybister convexus, C. tripunctatus* and *C. confuses* show significant over representation in acidic ponds where as the smaller species perhaps inhabit alkaline water bodies.

Salinity

Oligohaline or low salinity range is defined as salinity between 0.5 and 5 ‰ (ppt) where fresh and saline water meet, Day *et al*. (1989). The present studies involving the hydradephagan beetles suggest that all the 45 species collected during the study period belong to oligohaline group. Literature on the relationship between salinity and the abundance and distribution of hydradephagan beetles is very scanty. Baid (1959) has studied the insect life in Sambhar lake India, this shows considerable fluctuation in the salinity of water during the course of a year. The salinity may vary in this lake from 0.93‰ to over 16.0‰. The true lake species such as *Cybister tripunctatus asiaticus, Eretesstiticus, Hyphoporus severini* are oligohaline. These species occur in the lake only when the salinity is relatively low.

Studies show that most of the species collected have significant preferences or aversion to the various classes of salinity. Of the various species collected during the study except *Cybister convexus, C. confuses, Copelatusfeae. Hydroglyphus milleri* and *Laccophilus flexuosus* show significant under representation. In all other species almost over representation in all the salinity classes. Almost all the larger species like *Eretes, Hydaticus, Rhantaticus* and *Sandracottus* show significant over representation in salinity classes between 0.07-0.18‰. The smaller beetles belonging to Dytiscidae are having significant over representation at lower salinity. Noterids such as *Canthydrus,* gyrinids like *Dineutus, Gyrinus* and *Orectochilus* and haliplids have a significant over representation in the higher salinity classes.

The collection of beetles at salinity ranging from 0.04-0.22 ‰ (ppt) shows that the beetles can withstand a wide range of salinity. Minakava *et al.* (2001) while reporting on the salinity tolerance of the diving beetle *Hygrotus impresso punctatus* are of the view that the beetle could survive in seawater at least for 12 days and even they are flushed out to sea during floods many of the dytiscids could survive seawater and reach nearby land, if the distance is short enough. This may possibly be due to the thick integument which most likely minimizes water loss in seawater as suggested by Beament (1961). A number of beetles are significantly over represented at different salinities.

CONCLUSION

This study investigated the variation in the distribution and abundance of *Hydradephagan* beetles in response to the pH and salinity classes. The Index of Representation (I.R) shows that different species of aquatic beetles prefer different pH and salinity conditions, which may be used as indicator of changing pH and salinities.

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