International Journal of Fauna and Biological Studies
Available online at www.faunajournal.com

IJFBS International Journal of Fauna And Biological Studies

ISSN 2347-2677
IJFBS 2017; 4(1): 15-21
Received: 04-11-2016
Accepted: 05-12-2016

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Gastropod diversity with physico-chemical characteristics of water and soil in selected areas of Dakshina Kannada district of Karnataka, India

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Abstract
A study on population dynamics of freshwater and terrestrial gastropods and also physico-chemical characteristics of soil and water was studied during October 2008 to November 2009 at Mangalore, Bantwal and Puttur taluks of Dakshina Kannada. Gastropods were collected using the traditional method of handpicking and mean values of all the studied sites were taken to determine the density, frequency and abundance of these species. The physico-chemical characteristics of water and soil in the selected areas were analyzed using standard methods. Thirteen species of terrestrial gastropods belonging to six families and 6 species of freshwater gastropods belonging to five different families were observed and identified. Shannon diversity indices and Simpson's indices revealed the species richness and diversity were maximum at Mangalore when compared to the other two study locations. The value of physico-chemical parameters indicates that there was a moderate positive relation with the population dynamics of gastropods.

Keywords: Gastropod, population dynamics, Shannon diversity, water and soil quality

1. Introduction
Molluscans constitute the second largest invertebrates and the most successful group next only to insects (Bouchet, 1992) [5]. Based on their habitat preference, molluscs can be classified into aquatic and land communities. The terrestrial habitats are inhabited exclusively by class gastropoda and freshwater habitat by class bivalvia and gastropoda. Gastropoda is the largest and most successful class of molluscs with 75,000 living species and found in a wide range of habitats; freshwater, marine and terrestrial (Mavinkurve *et al*., 2004) [16]. Molluscs play a significant role as links in food chain as detritus feeders, improving bottom sediments and soil conditions (Barker, 1989; Martin, 1991; Reddy, 1995) [3, 15, 19]. Molluscan communities are sensitive to certain chemicals; many species are excellent water quality indicators of localized conditions. Many have limited migration patterns and are particularly well suited for assessing site-specific impacts. The presence of thriving population of molluscs indicates that the land is not acidic; hardly any molluscs survive beyond a pH of 5 (Boycott, 1934) [6]. The decline of freshwater snails began in the early twentieth century. Dam construction and other channel modifications, siltation, industrial and agricultural pollution have all degraded the river habitats on which most species depend. As a result, the species richness and the abundance of freshwater snails have declined dramatically. The continued loss and decline of freshwater snails and terrestrial species are testament to the fact that despite significant water-quality improvements made in last 25 years, much work remains if we are to halt species losses (Johnson, 2009) [10]. The habitat destruction by deforestation, construction works and industrialization is commonly seen and scaling up in Dakshina Kannada threatening the molluscan species in general and gastropod diversity in particular. In the present documentation on the occurrence of gastropod species in different habitats of Mangalore, Bantwal and Puttur were made. Their population status has also been assessed.

2. Materials and methods
Dakshina Kannada is the southern coastal district of Karnataka State, India with an area of 4866 sq. km. The district lies between 12^0 57' and 13^0 50' North Latitude and 74^0 10' and 75^0 50' East Longitude. The climate of the district is characterized by excessive humidity (78%) during the greater part of the year. Sampling was made at Mangalore, Bantwal and Puttur, these sites namely arecanut farm, paddy field and streams were selected for the analysis of

physico-chemical parameters and to assess the occurrence and distribution of gastropod species.

Gastropods were collected by using the traditional method of handpicking. The study was carried out during the period October 2008- November 2009. Sampling was carried out in a 10X50 m area of study site. Random sampling of gastropod was made in five plots of each studied site. In each plot the number of gastropods present were recorded and identified. The gastropods were collected at three different sites in the streams. The collected individuals were stored in 5% formalin. The identification of gastropods was made referring to "Fauna of British India" (Blanford and Godwin-Austin; 1908) [4] and other related literatures (Annandale and Prashad, 1920; Subba Rao, 1993; Kerney *et al*., 1983 and Falkner *et al*., 2002) [1, 23, 12, 9, 25].

The mean values of all the studied sites were taken to determine the density, frequency and abundance of these species using the following formulae;

a) Density: D = I/L x100. b) Frequency: F = n/N x100. c) Abundance: A = n/N

Shannon-Wiener diversity and Simpson's indices were determined for both freshwater and terrestrial gastropods.

The analysis physico-chemical parameters of the soil sample and water was made using standard procedure (APHA, 1996) [2].

3. Results and Discussion

The physico-chemical characteristics of water and soil in the studied sites of Dakshina Kannada are shown in Table 1-3. The relative population density, frequency and abundance of these species are shown in Figures 1-6. The graphic representation of Shannon diversity, and Simpson's index values are shown in Figure 7. Our investigation reveals the presence of six freshwater molluscs belonging to six families and thirteen terrestrial molluscs belonging to six families. Among the freshwater molluscs *Pila globosa; Neritina violacea; Lymnaea luteola; Thiara tuberculata* and *Indoplanorbis exustus* were dominant. Significant variations in density, frequency and abundance were observed in freshwater molluscans. From the Figure 1 it is evident that *Pila globosa* was found to be dominant over other species while, *Bellamya bengalensis* was found to be subdominant. The Shannon diversity index showed a maximum value at Mangalore (1.396) and minimum at Puttur (0). However Simpson's index value of freshwater gastropod diversity was found to be high at Puttur (1.0) followed by Bantwal (0.499) and Mangalore (0.283). This may be due to the variations of physico-chemical characteristics of water.

Among the gastropod recorded in Dakshina Kannada, six species namely *Pila globosa; Neritina violacea; Lymnaea luteola; Thiara tuberculata, Indoplanorbis exustus* and *Bellamya bengalensis* are distributed in streams (Plate I) and ten species namely *Lamelliaxis gracili; Kaliella barrakporensis; Leptopomoides valvatus; Cyclophorus indicus; Cyathopoma atrosetosum; Opeas sps; Machrochlamys sps; Succinea rugosa; Alycaeus footei* and *Glessula sps* are found in terrestrial habitat (Plate III). In addition to these snails three slugs namely *Mariaella dussumieri; Semperula sps* and *Laevicaulis alte* (Plate II) are found to be present in terrestrial habitat. The maximum distribution of nineteen species is seen in the habitats of Mangalore and the least number four species is found in Bantwal region.

According to Trojan (1992) [26] the density classes were accepted as Satellite species (D < 1%), subdominant (1< D < 5%) and dominant species (D < 5%). In light of this the analysis of our results regarding the distribution of gastropods in different habitat of different regions has been made. It is observed that the dominant terrestrial molluscans include *Mariaella dussumieri; Semperula sps; Lamelliaxis gracilis; Kaliella barrakporensis; Cyclophorus indicus; Leptopomoides valvatus; Cyathopoma atrosetosum; Opeas sps; Machrochlamys sps* and *Succinea rugosa.* Subdominant species were represented by *Laevicaulis alte; Alycaeus footei* and *Glessula sps* (Figure 2).

The climate and vegetation are important abiotic and biotic components which play a crucial role for distribution of molluscan species in a particular area. Most of the species recorded are found to be common between Mangalore, Bantwal and Puttur taluk. The distributions of these species in all these habitats vary owing to unequal distribution of rains. Rich diversity of terrestrial molluscs was found during rainy season. The drought season represents dry shells in majority. The moist places occurring near streams, canals, cascades and lakes represented high rate of diversity of the terrestrial molluscs species. But this is not applicable to every species and always appeared overlapping phenomenon regarding the distribution of molluscs species (Subba and Gosh, 2008) [24].

The physico-chemical characteristics of water and soil are represented in Table 1, 2 and 3, respectively. The parameters of freshwater namely temperature (28.50-30.50^0 C), pH (6.70-7.10), dissolved oxygen (7.10 – 7.70 mg/l), total alkalinity (24.50-35.00 mg/l), chlorides (7.20-10.20 mg/l), total hardness(15.20-17.50 mg/l), calcium (4.30-5.20 mg/l), magnesium (10.60-12.40 mg/l), inorganic phosphates (0.35-0.38 mg/l), sulphates (4.10-4.80 mg/l) and silicates (13.00-16.30 mg/l). Arecanut farm soil parameters, namely, temperature (30.50-33.50^0 C), pH (7.50-7.80), conductivity (125.20-154.40 µS/cm), moisture content (14.30-20.80 mg/l), total alkalinity(0.50-1.20 mg/l), chlorides (0.009-0.029 mg/l), nitrogen (0.23-0.29 mg/l), organic matter (2.30-2.90 mg/l), available phosphate (0.05-0.06 mg/l) and sulphates (12.30-16.60 mg/l) (Table 2) and also paddy field soil physico-chemical parameters were analyzed during the study period and shown in the Table 3.

The value of physico-chemical parameters indicate that there was a moderate positive relation between gastropods and temperature, pH, dissolved oxygen, total alkalinity, chlorides, total hardness, calcium, magnesium, inorganic phosphate, sulphates, silicates, conductivity, moisture content, nitrogen, organic matter and available phosphates. The water temperature had considerable influence on growth and development upon macro benthic organisms. In the present study temperature of water and soil is raised from 28.50-30.50^0 C and 29.50 – 33. 50^0 C was recorded.

Molluscs were represented in freshwater bodies by only two classes' gastropoda and pelecypoda (Mackie, 1998) and are group of most diverse and dominant benthic fauna in water bodies. Interestingly in our studies only gastropods are being observed. The richness of molluscans particularly *Pila globosa*, *Lymnaea luteola, Indoplanorbis exustus, Neritna violacea* and *Thiara tuberculata* and the least occurrence of *Bellamya bengalensis* was observed in the present study may be attributed to the cumulative effect of alkaline nature of water. High calcium content and macrophytic vegetation which provide both food and shelter because some of these forms are periphytic in nature as it has earlier documented by

Tonapi (1980) [25]. Pennak (1989) [18] also supported this point of view by observing greater molluscan population in alkaline lakes as compared to acidic lakes.

Water temperature exhibited a positive correlation with molluscs in the present study. This shows that increase in temperature within the observed range favors the growth of molluscs. Michael (1968) [17]; Dutta and Malhotra (1986) [8]; Malhotra *et al*., (1996) [14] and Garg *et al*., (2009) [11] also recorded a positive correlation between mollusks and temperature, while Ricker (1952) [20]; Srivastava (1956) [22] and Vasisht and Bhandal (1979) [27] noticed negative correlation between temperature and molluscs. Michael, (1968) [17] has however suggested that high temperature, alkalinity and food were probable cause for peak in abundance of zoobenthos during the summer months.

Molluscs were found to be independent of fluctuations with respect to pH, dissolved oxygen, total hardness and total alkalinity. Cheatum (1934) [7] and Sharma (1986) [21] have reported some molluscs can survive in very low oxygen condition and have noted inverse relationship. Chloride was found to be positively related to the molluscs but not to any significant extent. The increase in the hardness in water favors the growth of molluscs. Dutta and Malhotra (1986) [8] also found the predominance of molluscs fauna in a fish pond at Jammu due to higher concentration of calcium. Total alkalinity has favoured the abundance of molluscans in all the habitats of Dakshina Kannada. Such results of our study are in agreement with the work of Dutta and Malhotra (1986) [8]. Nutrient status such as phosphates, sulphates and nitrogen were found to be positively correlated with molluscs. The other factors such as organic matter, food, vegetation and silt also play a significant role in increase or decrease of molluscan population, density, frequency, abundance and diversity in lotic water bodies, paddy field and arecanut farms. Diversity indices such as Shannon H and Simpson's I-D were calculated for the gastropod species in the present work. Shannon diversity indices revealed the species richness of gastropods were more at Mangalore and Puttur in terrestrial habitat as compared to Bantwal while, Shannons index values showed a decrease in species richness of freshwater habitat at Puttur. Simpson's indices have shown that diversity of gastropod species is maximum at Mangalore, minimum at Puttur in freshwater habitats and moderate in Bantwal region, while high in terrestrial habitats in Mangalore and Puttur and minimum in Bantwal region. A low Simpson's index value equates high diversity.

Table 1: Quality parameters of water in Dakshina Kannada district.

Parameters	Mangalore	Bantwal	Puttur
Temperature (^{0}C)	30.50	28.50	28.50
pH	6.70	7.00	7.10
Dissolved Oxygen (mg/L)	7.70	7.40	7.10
Total Alkalinity (mg/L)	24.50	35.00	27.70
Chlorides(mg/L)	10.20	7.20	7.90
Total Hardness (mg/L)	16.30	17.50	15.20
Calcium (mg/L)	4.30	5.20	4.60
Magnesium (mg/L)	12.40	12.20	10.60
Inorganic Phosphates (mg/L)	0.35	0.38	0.36
Sulphates (mg/L)	4.40	4.80	4.10
Silicates (mg/L)	15.60	16.30	13.00

Table 2: Quality parameters of soil in arecanut farm in Dakshina Kannada district.

Parameters	Mangalore	Bantwal	Puttur
Temperature (^{0}C)	33.50	30.50	31.50
pH	7.80	7.50	7.70
Conductivity (µS/cm)	125.20	139.70	154.40
Moisture content	20.80	19.20	14.30
Chlorides (mg/L)	0.029	0.012	0.009
Total Alkalinity (mg/L)	1.20	0.50	0.90
Nitrogen (mg/L)	0.25	0.29	0.23
Organic matter (mg/L)	2.90	2.30	2.40
Available Phosphates (mg/L)	0.06	0.05	0.05
Sulphates (mg/L)	12.30	16.60	14.10

Table 3: Quality parameters of soil in paddy field in Dakshina kannada district.

Parameters	Mangalore	Bantwal	Puttur
Temperature (^{0}C)	32.50	29.50	30.50
pH	7.80	7.30	7.70
Conductivity (µS/cm)	127.20	133.70	156.40
Moisture content	14.10	13.50	20.00
Chlorides (mg/L)	0.005	0.006	0.014
Total Alkalinity (mg/L)	1.13	0.25	0.36
Nitrogen (mg/L)	0.18	0.17	0.21
Organic matter (mg/L)	2.15	1.59	1.47
Available Phosphates (mg/L)	0.06	0.05	0.05
Sulphates (mg/L)	12.30	15.80	13.70

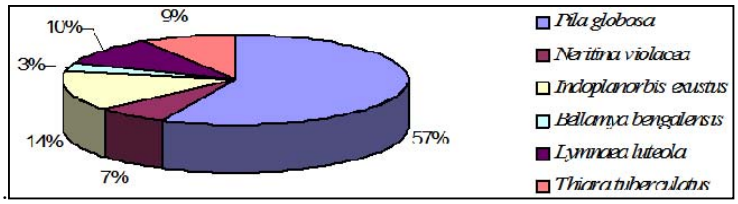

Fig 1: Mean population density of freshwater gastropod species.

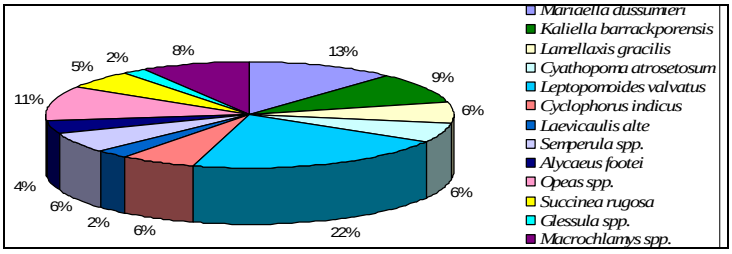

Fig 2: Mean population density of terrestrial gastropod species.

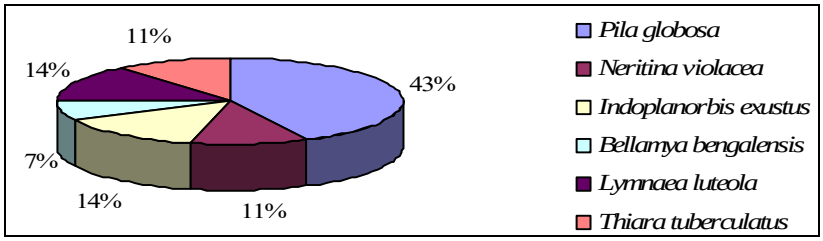

Fig 3: Percentage frequency of freshwater gastropod species.

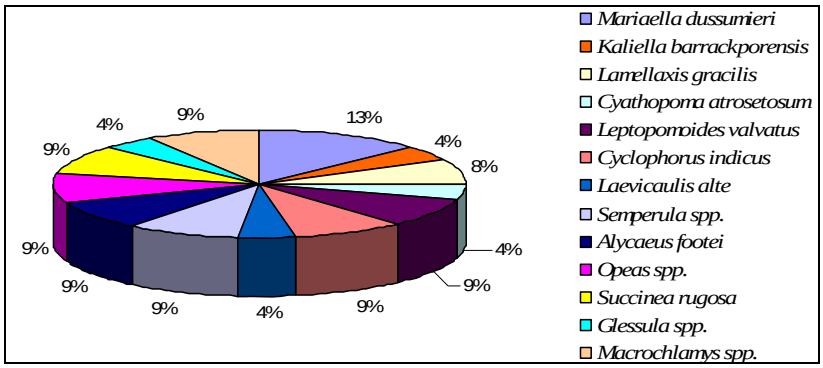

Fig 4: Percentage frequency of terrestrial gastropod species.

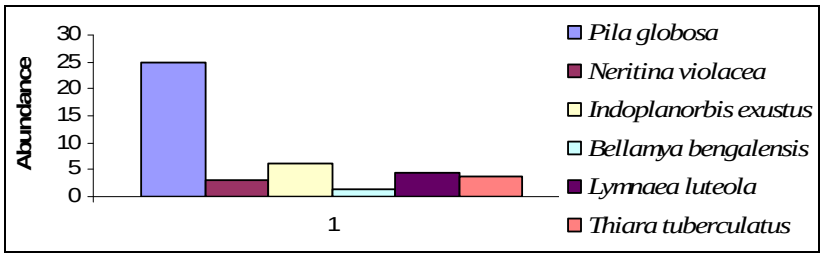

Fig 5: Relative abundance of different freshwater gastropods species.

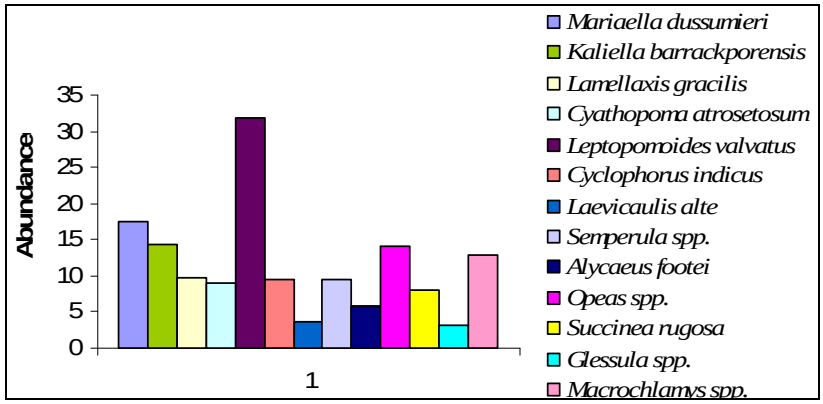

Fig 6: Relative abundance of different terrestrial gastropods species.

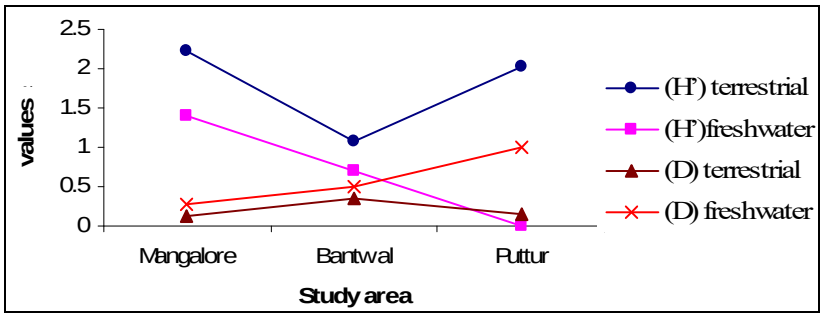

Fig 7: Shannon diversity (H') and Simpsons index (D) values for freshwater and terrestrial gastropods.

1 2 3

4 5 6

Plate 1

7 8 9

1-Pila globosa 2- Neritina violacea 3- Lymnaea luteola 4- Thiara tuberculata
5-Indoplanorbis exustus 6- Bellamya bengalensis.
7- Mariaella dussumieri 8- Semperula sps 9- Laevicaulis alte

Plate II

10 11 12

13 14 15

16 17 18 19

10-Lamelliaxis gracili 11- Kaliella barrakporensis 12- Leptopomoides valvatus 13- Cyclophorus indicus 14-Cyathopoma atrosetosum 15- Opeas sps 16-Machrochlamyssp17- Succinea rugosa 18- Alycaeus footei 19- Glessula *sps*

Plate III

4. Conclusion

From the above observations it can be inferred that most of the physico-chemical parameters of both soil and water play a significant role in growth and survival of molluscs population in Dakshina Kannada district. Ideally, this report will serve as a frame work to guide more detailed hypothesis of environmental complexity shaping gastropod distributions in Dakshina Kannada district. Understanding gastropod distribution may serve as a model for other lotic and terrestrial organisms, valuable for preserving endemic biodiversity and sustaining ecologically important species, by emphasizing the importance of niche distribution and abiotic environmental factors.

4. Acknowledgments

Authors are thankful to the Chairman, Department of Applied Zoology, Mangalore University, Mangalore, and to Dr Aravind Madhyastha for his valuable suggestions.

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