Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

J E Z S Journal of Entomology and Zoology Studies

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2019; 7(2): 1062-1067
© 2019 JEZS
Received: 15-01-2019
Accepted: 17-02-2019

ZA Wani
Div. of Vety. Parsitology, FVSc. & A.H, SKUAST-Kashmir, Jammu and Kashmir, India

RA Shahardar
Div. of Vety. Parsitology, FVSc. & A.H, SKUAST-Kashmir, Jammu and Kashmir, India

KH Bulbul
Div. of Vety. Parsitology, FVSc. & A.H, SKUAST-Kashmir, Jammu and Kashmir, India

Aiman Ashraf
Div. of Vety. Parsitology, FVSc. & A.H, SKUAST-Kashmir, Jammu and Kashmir, India

IM Allaie
Div. of Vety. Parsitology, FVSc. & A.H, SKUAST-Kashmir, Jammu and Kashmir, India

Azmat A Khan
Div. of LPM, FVSc. & A.H, SKUAST- Kashmir, Jammu and Kashmir, India

Syed Mudasir
Div. of Animal Biotechnology, FVSc. & A.H, SKUAST-Kashmir, Jammu and Kashmir, India

S Bilal
Div. of Vety. Biochemistry, FVSc. & A.H, SKUAST-Kashmir, Jammu and Kashmir, India

Gowhar Gul
Div. of Animal Nurtition, FVSc. & A.H, SKUAST- Kashmir, Jammu and Kashmir, India

Correspondence
ZA Wani
Div. of Vety. Parsitology, FVSc. & A.H, SKUAST-Kashmir, Jammu and Kashmir, India

Population density of snails in central zone of Kashmir valley

ZA Wani, RA Shahardar, KH Bulbul, Aiman Ashraf, IM Allaie, Azmat A Khan, Syed Mudasir, S Bilal and Gowhar Gul

Abstract
This study represents first of its kind to determine population density of snails in terms man hour collection/m^2 (MHC/m^2) in the Central Zone of Kashmir valley during August 2017-July 2018. Central zone of Kashmir valley comprises of 3 districts namely Budgam, Ganderbal and Srinagar. Snails were collected from different locations and based on morphological features were identified as *Radix lagotis*, *Radix brevicauda*, *Lymnaea luteola*, *Lymnaea stagnalis*, *Lymnaea auricularia*, *Indoplanorbis exustus*, *Bithynia troscheli*, *Physa acuta*, *Gyraulus ladacensis*, *Gyraulus pankogensis* and one unidentified snail. Overall mean population density in terms of MHC/m^2 for occurrence of snails was reported highest for *Physa acuta* snails (6.36±1.52), followed by *Lymnaea* snails other than *L. stagnalis* (4.69±1.07), *Lymnaea stagnalis* (3.83±0.89), *Gyraulus* spp. (3.25±0.88), *Indoplanorbis exustus* (2.25±0.94), *Bithynia troscheli* (2.13±0.98) and lowest for unidentified snail (0.31±0.31), the difference being statistically significant (p< 0.05) between L. *stagnalis*, *Physa acuta* and unidentified snail; *Lymnaea* snails other than *L. stagnalis* and unidentified snail; *Gyraulus* spp. and unidentified snail and non significant (p> 0.05) between *Lymnaea stagnalis*, *Lymnaea* snails other than *L. stagnalis*, *Indoplanorbis exustus*, *Bithynia troscheli*, and *Gyraulus* spp. Overall mean population density of all snails was observed highest in district Ganderbal followed by district Budgam and lowest for district Srinagar, the difference being statistically non significant (p> 0.05) for all snails between districts. Mean seasonal density of snails in terms of MHC/m^2 for district Budgam was reported highest in summer season followed by spring, autumn and lowest in winter season. For district Ganderbal, mean seasonal density of snails was reported highest in summer season followed by autumn, spring and lowest in winter season except for *Indoplanorbis exustus* and unidentified snail which showed higher density in summer followed by the spring season. In district Srinagar, mean seasonal density of snails was reported highest in summer season followed by spring, autumn and lowest in winter season except for *Indoplanorbis exustus* and unidentified snail which were reported in the spring and summer seasons only and *Bithynia troscheli* which showed higher density in summer and similar densities in autumn and spring seasons. *Lymnaea stagnalis*, *Lymnaea* snails other than *L. stagnalis* and *Physa acuta* were reported in winter season also and in all the 3 districts. This study is helpful in determining the prevalence of freshwater snails in the area which would furnish more information regarding the prevalence of trematode parasites in a particular region. This would further help in formulating control measures against economically important parasitic diseases of livestock prevalent in the area.

Keywords: Population density, MHC/m2, freshwater snails, central zone, Kashmir valley

1. Introduction
Freshwater gastropods (snails) which are an important and diverse component of aquatic ecosystems worldwide have diversified into every conceivable natural aquatic habitat including aquifers, springs, creeks, rivers, ponds, rice fields, lakes and wetlands and are routinely found in ephemeral and man-made water bodies [1]. Most of the snails graze on periphytic or epiphytic algae and biofilms, while some are suspension or deposit feeders. Freshwater snails are important as a primary intermediate host of all trematodes that cause several snail-borne diseases in human and various economically important animal species [2]. These diseases have a detrimental effect on public and veterinary health and thus need to be scientifically explored more extensively [3]. Hence, snail-borne diseases may be distributed across water resources. Distribution of freshwater gastropods depends on their abilities to colonize a habitat and survive there. Survival of gastropods in a particular habitat is regulated by various physico-chemical factors that play a major role to determine the ecological traits associated with a particular species. Various detailed qualitative surveys since the 1930s have shown that hardness, pH, altitude, size of water bodies, temperature, vegetation, and pollution

are among the significant aspects influencing the distribution and abundance of molluscs [4]. Population dynamics of snails also depend on the physical geography of a given region, land contours, soil composition, hydrography and climate. An intimate relationship between gastropod diversity and vegetation has been recorded [5]. Many species spend their entire lives in a few square meters of habitat, making them extremely vulnerable to localized environmental habitat degradation. Even though snail populations grant higher trematode diversity, trematodes can affect snail populations by directly reducing the egg production or by increasing snail mortality rates [6]. The presence of susceptible snail host is a primary requirement for the perpetuation of snail borne parasitic infections. In order to evolve a long term strategic control measures against snail-borne parasitic diseases, it is necessary to know the distribution pattern of snail vectors [7]. The snail counts per unit of time method measures the density of the snail population in the marked area only but not the total population [8]. Studies on the diversity, occurrence, density and abundance of freshwater snails on population dynamics have been carried out in India and abroad as well [9, 10, 11, 12, 13]. In Jammu and Kashmir study has carried out on the prevalence of snails only by Dhar *et al*. [14] and no study on population density has been carried out so far. Therefore, the present study was undertaken to determine the population density of snails in the Central Zone of Kashmir Valley.

2. Materials and Methods

2.1 Study area

The study was conducted in Central Zone of Kashmir Valley comprising of 3 districts *viz*. Budgam, Ganderbal and Srinagar. Budgam district is situated at an average height of 5,281 ft. above sea-level and at 75 degree E longitude and 34 degree N latitude. Ganderbal is located in north-east of Kashmir valley situated at 34.23ºN latitude and 74.78ºE longitude with an average altitude of 5,312 ft. above sea level. Srinagar district is situated at an average height of 5200 ft. above sea-level and at 34º5′23″N and 74º47′24″E. In Central Kashmir, summers are usually mild with good little rain, but relative humidity is generally high and nights are cool. The precipitation occurs throughout the year and no month is particularly dry. The hottest month is July (maximum temperature of 32^0C and minimum temperature 6^0C) and coldest are December-January (max. tempt.0^0C and minimum tempt. -15^0C). Vegetation and organic debris in these districts is of moderate type.

2.2 Population density of snails

The study was carried out from 10 am to 4pm of the day. Different locations (ponds, lakes, marshy areas, temporary water bodies, paddy fields and stagnant water bodies) in each district were surveyed to record the population density of snails. The population density of snails was calculated in terms of man per hour collection (MHC) per unit area (per m^2). The technique involved counting the number of snails that were collected systematically with sieves mounted on handles or handpicked by one or more experienced collectors in a measured and marked area (quadrate). One sq. m area was taken as a quadrate. Species of snails that fell within the quadrate were counted and recorded for calculation of population density of the snails.

2.3 Identification of snails

For identification based on the shell characteristics, snail shells were sent to the Zoological Survey of India, Calcutta (ZSI, Moll: I.R.No.107).

2.4 Statistical analysis

The results were subjected to standard statistical analysis as per Snedecor and Cochran [15].

3. Results and Discussion

The study was carried out from August 2017-July 2018, during which a total of 12,103 snails were collected from different locations in the Central Zone of Kashmir valley. Based on morphological characteristics, snails were identified as *Radix lagotis*, *Radix brevicauda*, *Lymnaea luteola*, *Lymnaea stagnalis*, *Lymnaea auricularia*, *Indoplanorbis exustus*, *Bithynia troscheli*, *Physa acuta*, *Gyraulus ladacensis*, *Gyraulus pankogensis* and one unidentified snail (ZSI, Moll:I.R.No.107). The population density was recorded for *Lymnaea stagnalis*, *Lymnaea* snails other than L. *stagnalis*, *Indoplanorbis exustus*, *Bithynia troscheli*, *Physa acuta*, *Gyraulus* spp. and unidentified snail.

3.1 Overall population density of snails in Central Zone of Kashmir Valley in terms of MHC/m^2

Overall mean population density in terms of MHC/m^2 for occurrence of snails varied from 0.31±0.31to 6.36±1.52 with highest mean density being observed for *Physa acuta* snails (6.36±1.52), followed by *Lymnaea* snails other than L. *stagnalis* (4.69±1.07), *Lymnaea stagnalis* (3.83±0.89), *Gyraulus* spp. (3.25±0.88), *Indoplanorbis exustus* (2.25±0.94), *Bithynia troscheli* (2.13±0.98) and lowest for unidentified snail (0.31±0.31), the difference being statistically significant ($p < 0.05$) between L. *stagnalis*, *Physa acuta* and unidentified snail; *Lymnaea* snails other than L. *stagnalis* and unidentified snail; *Gyraulus* spp. and unidentified snail and non significant ($p > 0.05$) between *Lymnaea stagnalis*, *Lymnaea* snails other than L. *stagnalis*, *Indoplanorbis exustus*, *Bithynia troscheli*, and *Gyraulus* spp. Overall mean population density of snails was observed highest in district Ganderbal followed by district Budgam and lowest for district Srinagar, the difference being statistically non significant ($p > 0.05$) for all snails between districts (Table 1). The present results are related to the findings of Gupta *et al*. [16] who studied the bionomics of aquatic snails *Lymnaea luteola*, *L. acuminata* and *Gyraulus convexiusculus* in Harayana state and reported variation in populations of snail species from locality to locality. In district Budgam mean population density was reported highest for *Physa acuta* (5.92±1.29) followed by *Lymnaea* snails other than *L. stagnalis* (4.33±0.99), *L. stagnalis* (3.42±0.84), *Gyraulus* spp. (3.00±0.88), *Indoplanorbis exustus* (1.92±0.80), *Bithynia troscheli* (1.83±0.67) and lowest for unidentified snail (0.25±0.13), the difference being statistically significant ($p < 0.05$) between *L. stagnalis*, *Physa acuta* and unidentified snail; *Lymnaea* snails other than *L. stagnalis* and unidentified snail; *Indoplanorbis exustus* and *Physa acuta; Bithynia troscheli* and *Physa acuta*; *Gyraulus* spp. and unidentified snail and non significant ($p>0.05$) between other snails (Table 1). District Ganderbal also showed mean population density highest for *Physa acuta* (8.33±2.04) followed by *Lymnaea* snails other than *L. stagnalis* (6.00±1.23), *L.stagnalis* (5.17±0.99), *Gyraulus* spp. (4.42±0.98), *Indoplanorbis exustus* (3.17±1.09), *Bithynia troscheli* (3.08±0.61) and lowest for unidentified snail (0.50±0.15), the difference being statistically significant ($p < 0.05$) between L. *stagnalis* and unidentified snail; *Lymnaea* snails other than *L. stagnalis* and unidentified snail; *Indoplanorbis exustus* and *Physa acuta; Bithynia troscheli* and *Physa acuta*; *Physa acuta*, *Gyraulus* spp. and unidentified snail and non significant (p >0.05) between other snails (Table 1). District Srinagar also showed mean population density highest for *Physa acuta* (4.83±1.11) followed by *Lymnaea* snails other than L. *stagnalis* (3.75±0.89), L. *stagnalis* (2.92±0.68), *Gyraulus* spp. (2.33±0.62), *Indoplanorbis exustus* (1.67±0.63), *Bithynia troscheli* (1.50±0.44) and lowest for unidentified snail (0.17±0.11), the difference being statistically significant (p< 0.05) between L. *stagnalis* and unidentified snail; *Lymnaea* snails other than L. *stagnalis* and unidentified snail; *Indoplanorbis exustus* and *Physa acuta*; *Physa acuta*, *Gyraulus* spp. and unidentified snail; *Bithynia troscheli* and *Physa acuta* and non significant (p >0.05) between other snails (Table 1). Hicham *et al*. [17] reported the mean densities of *Physa acuta* ranging from 0 to 34.5, *Lymnaea pergera* from 0 to 8.9, *Lymnaea truncatula* from 0.5 to 2.6 and *Lymnaea stagnalis* from 0 to 2.5 in different habitats of Gharb area of Morroco. Owojori *et al*. [18] reported the density of snails as high as 45.8 and as low as 0.7 among 11 sites in Opa Reservoir and Research farm ponds, Nigeria. Zukowski and Walker [19] reported *Physa acuta* to be most abundant snail in lower river Murray, Australia. The study is in contradiction with Islam *et al*. [20] who reported highest density for *Indoplanorbis exustus* (32±0.23), followed by *Lymnaea luteola* (24±0.27) and lowest for *Lymnaea auricularia* (16±0.18) in some selected areas of Mymensingh, Bangladesh. The variation in the results with respect to other workers may be because of variation in climatic factors and topography of the surveyed regions. The difference in area wise density of snails may be because of the presence or absence of water reservoirs, canals, rivers and also due to environmental and managemental conditions. The highest density of snails in district Ganderbal is because environmental conditions are more suitable for the snails breeding, as there are many lakes, streams and river. Variation in district wise density of snails is also due to the fact that district Srinagar and district Budgam are comparatively well drained and around district Ganderbal there are enough marshy areas which favor the development of snails. Juvenile *P. acuta* has been reported to grow more rapidly in water conditioned by *Lymnaea* snails suggesting an effect of pheromones or metabolites. In Kashmir valley usually mixed populations of snails occur at a particular location, which may explain its highest occurance and density in all the districts, but this needs further verification. *Physa acuta* is a “weedy” species [4] and occurs in greatest abundance where there is a moderate amount of aquatic vegetation and organic debris [21, 22]. This may also be the reason for highest density of *Physa acuta* in these districts.

3.2 District wise seasonal population density of snails in Central Zone of Kashmir Valley in terms of MHC/m^2

3.2.1 District Budgam

Seasonal density of snails was reported highest in summer followed by spring, autumn and lowest in winter season for all the reported snails, however in autumn season *Physa acuta* (5.33±0.88) showed highest mean density followed by *Lymnaea* snails other than *L. stagnalis* (3.33±0.67), *L. stagnalis* (2.33±0.88), *Gyraulus* spp. (2.00±1.15) and *Bithynia troscheli* (1.33±0.67). *Indoplanorbis exustus* was not recorded during autumn season, the difference being statistically significant (p< 0.05) between *L. stagnalis* and *Physa acuta*; *Physa acuta* and *Gyraulus* spp. *Bithynia troscheli* and *Physa acuta* and non significant (p >0.05) between other snails. In winter density of *Lymnaea* snails other than *L. stagnalis* (0.67±0.33) was higher followed by *L. stagnalis* and *Physa acuta* (0.33±0.33 each), the difference being statistically non significant (p >0.05). Other snails were not recorded. Spring season recorded highest density for *Physa acuta* (6.00±1.00) followed by *Lymnaea* snails other than *L. stagnalis* (4.33±0.88), *L. stagnalis* (3.67±0.33), *Gyraulus* spp. (3.00±0.58), *Indoplanorbis exustus* (2.33±0.67), *Bithynia troscheli* (2.00±1.00) and lowest for unidentified snail (0.33±0.33), the difference being statistically significant (p< 0.05) for *L. stagnalis* and unidentified snail; *Lymnaea* snails other than *L. stagnalis* and unidentified snail; *Indoplanorbis exustus* and *Physa acuta*; *Bithynia troscheli* and *Physa acuta*; *Physa acuta* and unidentified snail; *Physa acuta* and *Gyraulus* spp.; *Gyraulus* spp. and unidentified snail and non significant (p >0.05) between other snails. Summer season recorded highest density for *Physa acuta* (12.00±1.00) followed by *Lymnaea* snails other than *L. stagnalis* (9.00±1.53), *L. stagnalis* (7.33±1.20), *Gyraulus* spp. (7.00±1.53), *Indoplanorbis exustus* (5.33±2.03), *Bithynia troscheli* (4.00±2.08) and lowest for snail yet to be identified (0.67±0.33), the difference being statistically significant (p< 0.05) between *L. stagnalis* and unidentified snail; *Lymnaea* snails other than *L. stagnalis* and unidentified snail; *Lymnaea* snails other than *L. stagnalis* and *Bithynia troscheli*; *Bithynia troscheli* and *Physa acuta*; *Physa acuta* and unidentified snail; *Physa acuta* and *Gyraulus* spp.; *Gyraulus* spp. and unidentified snail and non significant (p >0.05) between other snails (Table 1). Afshan *et al*. [23] reported highest abundance of snails in summer and lowest in winter season at Pothwar Region, Pakistan. Brown [24] also stated that the summer rainy season provides optimum conditions for the availability of freshwater snails. Karimi *et al*. [25] recorded the highest abundance of snails in summer followed by autumn and winter and lowest during spring season. The present results are also supported by the observations of Pokhriyal *et al*. [26] who observed the occurrence of *Lymnaea* snails throughout the year in Doon Valley.

3.2.2 District Ganderbal

Almost a similar pattern of density was recorded for all seasons as observed in district Budgam, but *Bithynia troscheli* and *L. stagnalis* were reported higher in summer followed by autumn, spring and winter. In autumn season *Physa acuta* (8.00±1.53) showed highest density followed by *Lymnaea* snails other than *L. stagnalis* (6.66±1.45), *L. stagnalis* (5.67±0.88), *Gyraulus* spp. (5.00±1.00) and *Bithynia troscheli* (4.00±0.58) and unidentified snail (0.33±0.33). *Indoplanorbis exustus* was not recorded during the autumn season, the difference being statistically non significant (p >0.05) between all snails except for unidentified snail which differed significantly (p< 0.05) with other snails. In winter density of *L. stagnalis* (0.67±0.33) was higher followed by *Lymnaea* snails other than *L. stagnalis* and *Physa acuta* (0.33±0.33 each), the difference being statistically non significant (p >0.05). Other snails were not recorded. Spring season recorded highest density for *Physa acuta* (7.00±1.00) followed by *Lymnaea* snails other than *L. stagnalis* (6.00±1.15), *L. stagnalis* (5.00±1.15), *Indoplanorbis exustus* (4.33±1.45), *Gyraulus* spp. (4.00±1.00), *Bithynia troscheli* (3.00±0.00) and lowest for unidentified snail (0.67±0.33), the difference being statistically significant ($p < 0.05$) for *L. stagnalis* and unidentified snail; *Lymnaea* snails other than *L. stagnalis* and unidentified snail; *Indoplanorbis exustus* and unidentified snail; *Bithynia troscheli* and *Physa acuta*; *Physa acuta* and unidentified snail; *Gyraulus* spp. and unidentified snail and non significant (p >0.05) between other snails. Summer season recorded highest density for *Physa acuta* (18.00±3.05) followed by *Lymnaea* snails other than *L. stagnalis* (11.00±1.00), *L. stagnalis* (9.33±0.67), *Gyraulus* spp (8.67±0.33), *Indoplanorbis exustus* (8.33±0.33), *Bithynia troscheli* (5.33±0.33) and lowest for snail yet to be identified (1.00±0.00), the difference being statistically significant ($p < 0.05$) for *L.stagnalis*, *Physa acuta* and unidentified snail; *Lymnaea* snails other than *L. stagnalis*, *Physa acuta*, *Bithynia troscheli* and unidentified snail; *Indoplanorbis exustus*, *Physa acuta* and unidentified snail; *Physa acuta*, *Gyraulus* spp. and unidentified snail and non significant (p >0.05) between other snails (Table 1). Abd El-Wakeil *et al*. [27] recorded maximum species richness and diversity of molluscan community in spring and summer months in River Nile and its branches at Assiut governorate, Egypt. Qureshi *et al*. [28] also reported significantly higher number of snails during summer and lower during winter season. Bulbul [13] reported *Indoplanorbis exustus* higher in summer followed by autumn and spring in 3 districts of Assam.

3.2.3 District Srinagar

Seasonal density of snails was reported highest in summer followed by spring, autumn and lowest in winter season. Autumn season recorded highest density for *Physa acuta* (4.00±1.00) followed by *Lymnaea* snails other than *L. stagnalis* (3.33±1.67), *L.stagnalis* (2.00±0.00), *Gyraulus* spp. (1.67±0.88), *Bithynia troscheli* (1.33±0.67). *Indoplanorbis exustus* was not recorded during autumn season, the difference being statistically non significant (p >0.05). In winter density of *Lymnaea* snails other than *L. stagnalis*, *L. stagnalis* and *Physa acuta* was similar (0.33±0.33 each), the difference being statistically non significant (p >0.05). Other snails were not recorded. In spring season *Physa acuta* (5.00±1.00) showed highest density followed by *Lymnaea* snails other than *L. stagnalis* (4.00±1.00), *L. stagnalis* (3.33±0.67), *Gyraulus* spp. (2.67±0.33), *Indoplanorbis exustus* (2.00±1.00), *Bithynia troscheli* (1.33±0.88) and lowest for unidentified snail (0.33±0.33), the difference being statistically significant ($p < 0.05$) for *L. stagnalis* and unidentified snail; *Lymnaea* snails other than *L. stagnalis* and *Bithynia troscheli*; *Lymnaea* snails other than *L. stagnalis* and unidentified snail; *Bithynia troscheli* and *Physa acuta*; *Gyraulus* spp. and unidentified snail and non significant (p >0.05) between other snails. Summer season recorded highest density for *Physa acuta* (10.00±1.00) followed by *Lymnaea* snails other than *L. stagnalis* (7.33±1.20), *L. stagnalis* (6.00±1.00), *Gyraulus* spp. (5.00±1.00), *Indoplanorbis exustus* (4.67±0.67), *Bithynia troscheli* (3.33±0.33) and lowest for snail yet to be identified (0.33±0.33), the difference being statistically significant ($p < 0.05$) for *L. stagnalis*, *Physa acuta* and unidentified snail; *Lymnaea* snails other than *L. stagnalis*, *Bithynia troscheli*, *Physa acuta* and unidentified snail; *Indoplanorbis exustus*, *Physa acuta* and unidentified snail; *Physa acuta*, *Gyraulus* spp. and unidentified snail and non significant (p >0.05) between other snails (Table 1). The study is partially contradictory with Saddozai *et al*. [29] who reported higher population of *Lymnaea* snails as compared to *Physa acuta* and *Gyraulus eupharaticus*, but also reported gastropods higher in summer and lowest in winter season in Manchar lake Sindh, Pakistan. Lacoursiere *et al*. [30] and Vincent *et al*. [31] suggested that gastropod variability is due to abiotic factors (depth, current and sediment). Also Strzelec and Królczyk [11] reported that many gastropod species are tolerant to most physicochemical water parameters and their occurrence is affected by the quality of bottom sediments and vegetation abundance. This may further explain the variation in densities of snails in these districts. *P. acuta* is often associated with warm, disturbed environments and its ability to spread rapidly and populate areas may be due partly to its quick responses to changing water temperatures [32]. *Lymnaea* snails also have explosive growth because of high reproductive rates under favorable conditions [33]. So, small populations can quickly recover in number, as individuals are capable of self-fertilization [34]. The temperature plays a vital role in the physiology of molluscan fauna and as per Aziz *et al*. [35] 30 ºC is highly significant as far as the duration of reproduction of gastropods is concerned and according to Pennak [22] 30 ºC is the critical temperature at which mostly the species survive, which in Kashmir valley occurs during summer months. The eggs of freshwater pulmonates also develop more quickly at warmer temperatures [36], so snails attain the highest density in warm seasons as compared to others. More freshwater snails collected in the spring as compared to autumn season is due to the fact that during spring snow melts and frequent rains cause rapid accumulation of water and also temperature is usually above 20^0C which is favourable for most of the snails.

Table 1: Seasonal Population density of snails in Central zone of Kashmir Valley (Man / hour/m2)

Area	**Season**	***Lymnaea stagnalis***	***Lymnaea* spp. (other than L. *stagnalis*)**	***Indoplanorbis exustus***	***Bithynia troscheli***	***Physa Acuta***	***Gyarulus* spp.**	**Unidentified snail**
Budgam	Autumn	$2.33{\pm}0.88^{abAB}$	$3.33{\pm}0.67^{bcAB}$	$0.00{\pm}0.00^{aA}$	$1.33{\pm}0.67^{ab}$	$5.33{\pm}0.88^{cB}$	$2.00{\pm}1.15^{abA}$	$0.00{\pm}0.00^{a}$
	Winter	$0.33{\pm}0.33^{A}$	$0.67{\pm}0.33^{A}$	$0.00{\pm}0.00^{A}$	$0.00{\pm}0.00^{A}$	$0.33{\pm}0.33^{A}$	$0.00{\pm}0.00^{A}$	0.00±0,00
	Spring	$3.67{\pm}0.33^{bcB}$	$4.33{\pm}0.88^{bcB}$	$2.33{\pm}0.67^{abAB}$	$2.00{\pm}1.00^{ab}$	$6.00{\pm}1.00^{cB}$	$3.00{\pm}0.58^{bA}$	$0.33{\pm}0.33^{a}$
	Summer	$7.33{\pm}1.20^{bcdC}$	$9.00{\pm}1.53^{cdC}$	$5.33{\pm}2.03^{abcB}$	$4.00{\pm}2.08^{ab}$	$12.00{\pm}1.00^{dC}$	$7.00{\pm}1.53^{bcB}$	$0.67{\pm}0.33^{a}$
	Average	$3.42{\pm}0.84^{bcA}$	$4.33{\pm}0.99^{bcA}$	$1.92{\pm}0.80^{abA}$	$1.83{\pm}0.67^{abA}$	$5.92{\pm}1.29^{cA}$	$3.00{\pm}0.88^{bA}$	$0.25{\pm}0.13^{aA}$
Ganderbal	Autumn	$5.67{\pm}0.88^{bcB}$	$6.66{\pm}1.45^{bcB}$	$0.00{\pm}0.00^{aA}$	$4.00{\pm}0.58^{bB}$	$8.00{\pm}1.53^{cB}$	$5.00{\pm}1.00^{bcB}$	$0.33{\pm}0.33^{aAB}$
	Winter	$0.67{\pm}0.33^{A}$	$0.33{\pm}0.33^{A}$	$0.00{\pm}0.00^{A}$	$0.00{\pm}0.00^{A}$	$0.33{\pm}0.33^{A}$	$0.00{\pm}0.00^{A}$	$0.00{\pm}0.00^{A}$
	Spring	$5.00{\pm}1.15^{bcB}$	$6.00{\pm}1.15^{bcB}$	$4.33{\pm}1.45^{bcB}$	$3.00{\pm}0.00^{abB}$	$7.00{\pm}1.00^{cB}$	$4.00{\pm}1.00^{bcB}$	$0.67{\pm}0.33^{aAB}$
	Summer	$9.33{\pm}0.67^{bcC}$	$11.00{\pm}1.00^{cC}$	$8.33{\pm}0.33^{bcC}$	$5.33{\pm}0.33^{bC}$	$18.00{\pm}3.05^{dC}$	$8.67{\pm}0.33^{bcC}$	$1.00{\pm}0.00^{aB}$
	Average	$5.17{\pm}0.99^{bcA}$	$6.00{\pm}1.23^{bcA}$	$3.17{\pm}1.09^{abA}$	$3.08{\pm}0.61^{abA}$	$8.33{\pm}2.04^{cA}$	$4.42{\pm}0.98^{bA}$	$0.50{\pm}0.15^{aA}$
Srinagar	Autumn	$2.00{\pm}0.00^{abAB}$	$3.33{\pm}1.67^{bA}$	$0.00{\pm}0.00^{aA}$	$1.33{\pm}0.67^{abA}$	$4.00{\pm}1.00^{bB}$	$1.67{\pm}0.88^{abAB}$	$0.00{\pm}0.00^{a}$
	Winter	$0.33{\pm}0.33^{A}$	$0.33{\pm}0.33^{A}$	$0.00{\pm}0.00^{A}$	$0.00{\pm}0.00^{A}$	$0.33{\pm}0.33^{A}$	$0.00{\pm}0.00^{A}$	0.00±0.00
	Spring	$3.33{\pm}0.67^{bcdB}$	$4.00{\pm}1.00^{cdAB}$	$2.00{\pm}1.00^{abcA}$	$1.33{\pm}0.88^{abA}$	$5.00{\pm}1.00^{dB}$	$2.67{\pm}0.33^{abcdB}$	$0.33{\pm}0.33^{a}$
	Summer	$6.00{\pm}1.00^{bcC}$	$7.33{\pm}1.20^{cB}$	$4.67{\pm}0.67^{bcB}$	$3.33{\pm}0.33^{bB}$	$10.00{\pm}1.00^{dC}$	$5.00{\pm}1.00^{bcC}$	$0.33{\pm}0.33^{a}$

	Average	2.92±0.68[bcdA]	3.75±0.89[cdA]	1.67±0.63[abcA]	1.50±0.44[abA]	4.83±1.11[dA]	2.33±0.62[bcA]	0.17±0.11[aA]
	Total	3.83±0.89[b]	4.69±1.07[bc]	2.25±0.94[ab]	2.13±0.98[ab]	6.36±1.52[c]	3.25±0.88[b]	0.31±0.31[a]

Mean Density values of different snail types along the rows bearing different small case superscripts differ significantly

Mean Density values for a particular snail type between seasons (along the columns) in a particular district bearing different upper case superscripts differ significantly

4. Conclusion

The present communication documents the population density of snails in Central Zone of Kashmir valley in terms of man per hour/m2. The study reveals that overall mean population density was reported highest for *Physa acuta* snails and lowest for unidentified snail. Out of all the identified snails, *Lymnaea* snails and *Physa acuta* were reported throughout the year. The study indicates that climatic factors and vegetation plays an important role in determining the densities of snails, which is evident in terms of seasonal fluctuations in population density of snails. The study further paves way for understanding the influence of climatic factors on the prevalence of freshwater snails. The density of fresh water snails provides information regarding intensity of different snail species prevalent in the Central zone of Kashmir Valley which would further help us to know the occurrence of different trematode parasites in a particular area. The distribution of freshwater snails would help in formulating appropriate strategies to control snail population which could further reduce the cost of treating the animal for trematode infections.

5. Acknowledgement

The authors are highly thankful to staff of Parasitology Division (SKUAST-K), Shuhama especially to Mr. Ghulam Rasool Wani, Mr. Mohd. Amin wani, Mr. Javid Ah. Dar and Mr. Nazir Ah. Ganaie for providing assistance and nice company during the research programme. The first author has no words to express sincere thanks to Mr. Ghulam Rasool Wani who provided tremendous help during exhaustive sampling and processing of snails in the laboratory.

6. References

1. Johnson PD, Bogan AE, Brown KM, Burkhead NM *et al*. Conservation status of freshwater gastropods of Canada and the United States. Fisheries. 2013; 38:247.282.
2. Hong SJ, Woo H C, Lee SU, Huh S. Infection status of dragon flies with *Plagiorchis muris* Metacercariae in Korea, Korean Journal of Parasitology. 1999; 37:65-70.
3. Supian Z, Ikhwanuddin AM. Population dynamics of freshwater molluscs (Gastropod: *Melanoides tuberculata*) in Crocker Range Park, Sabah. Asean Review of Biodiversity and Environmental Conservation (ARBEC), 2002, 1-9.
4. Dillon RT Jr. The ecology of fresh water Mollusca. Cambridge University Press, Cambridge, U.K, 2000.
5. Sinha KK, Sinha DK. Observation on macrophytes associated benthic macrofauna in some freshwater ponds of Munger (Bihar). Journal of Ecobiology. 1993; 5:89-93.
6. Lafferty KD. Effects of parasitic castration on growth, reproduction and population dynamics of the marine snail (C*eritedia californica*). Marine ecology. Progress series. 1993; 96:229-237.
7. Devi P, Islam S, Das M. Prevalence of freshwater snails in Assam. Journal of Veterinary Parasitology. 2006; 20:81-84.
8. Oliver L, Scheidermans M. A method for estimating the density of aquatic snail populations. Experimental Parasitology. 1956; V:109-117.
9. Satyamurthi ST. The land and freshwater molluscs in the collection of the Madras Government Musseum. Bulletin Madras Government Musseum (Natural History Series). 1960; 6:1-174.
10. Silva M, Júlia M, Barros, M. Occurrence and distribution of fresh-water molluscs in the Riacho Fundo Creek Basin, Brasilia, Brazil. Revista de biología Tropical. 2001; 49:110-115.
11. Strzelec, M, Krolezyk A. Factors affecting snail (Gastropoda) community structure in the upper course of the Warta River (Poland). Biologia Bratislava. 2004; 59:159-163.
12. Tigga M N, Bauri R K, Deb AR, Kullu S S. Prevalence of snail’s intermediate host infected with different Trematodes Cercariae in and around Ranchi. Veterinary World. 2014; 7:630-34.
13. Bulbul KH. Studies on *Indoplanorbis exustus* and its associated Schistosomes. Ph.D., Thesis submitted to Assam Agricultural University, Guwahati, 2016.
14. Dhar D N, Bansal GC, Sharma RL. Studies on aquatic snails of Kashmir Valley with particular reference to *Lymnaea auricularia* sensu stricto. Indian Journal of Parasitology. 1985; 9:241-244.
15. Snedecor GW, Cochran WG. Statistical methods. 8th Edition.Iowa state University Press. Iowa, USA. 1994.
16. Gupta RP, Yadav CL, Ruprah NS. Studies on bionomics of some aquatic snails and their cercarial fauna of Harayana State. Indian Journal of Veterinary Medicine. 1987; 11:77-83.
17. Hicham B, Barkia A, Yacoubi R, EL-Guemri Y, El-Madhi, Y, Belghyti D. Trematode infection among freshwater gastropods in the Gharb area, Morocco. Journal of Environment and Earth Science. 2015; 5:174-181.
18. Owojori OJ, Asaolu SO, Ofoezie IE. Ecology of freshwater snails in Opa reservoir and research farm ponds at Obafemi awolowo University lfe-lfe, Nigeria. Journal of Applied Sciences. 2006; 6:3004-3015.
19. Zukowski S, Walker KF. Freshwater snails in competition: alien *Physa acuta* (Physidae) and native *Glyptophysa gibbosa* (Planorbidae) in the River Murray, South Australia. Marine and Freshwater Research. 2009; 60:999–1005.
20. Islam Z, Alam, M Z, Akter S, Roy BC, Mondal M M H. Distribution Patterns of Vector Snails and Trematode Cercaria in their vectors in some selected Areas of Mymensingh. Journal of Environmental Science and Natural Resources. 2012; 5:37- 46.
21. Smith DG. Pennak’s Freshwater Invertebrates of the United States, 4th Edition. John Wiley and sons, New York. 2001, 327-400.
22. Pennak RW. Freshwater invertebrates of United States. New York, 1953, 1-768.
23. Afshan K, Beg M A, Ahmad I, Ahmad M M, Qayyum M. Freshwater Snail fauna of Pothwar Region, Pakistan. Pakistan Journal of Zoology. 2013; 45:227-233.
24. Brown DS. Freshwater snails of Africa and their medical importance. Taylor and Francis Ltd., London. 1980, 487.
25. Karimi GR, Derakhshanfar M, Paykari H. Population

Density. Trematodal infection and ecology of *Lymnaea* Snails in Shadegan, Iran. Archives of Razi Institute. 2004; 58:125-129

26. Pokhriyal BP, Mahesh RK, Jauhari RK. Prevalence of trematode cercarial infection in the snail *Lymnaea* (*Pseudosuccinea*) *acuminata* Lamarck, 1822 in different localities of Dehradun Valley. Bioved Journal. 1997; 8:15-19.
27. Abd El-Wakeil KF, Obuid-Allah A H, Mohamed A H, Abd El-Aziz FA. Community structure of molluscs in River Nile and its branches in Assiut governorate, Egypt. Egyptian Journal of Aquaculture Research. 2013; 39:193-8.
28. Qureshi AW, Tanveer A, Maqbool A, Niaz S. Prevalence and trematode infection of freshwater snails with emphasis on fasciolosis in Punjab, Pakistan Asian Journal of Agricultural Biology. 2015; 3:130-139.
29. Saddozai S, BalochW A, Achakzai1 M, Memon N. Population dynamics and ecology of freshwater gastropods in Manchar Lake, Sindh, Pakistan. The Journal of Animal & Plant Sciences. 2013; 23:1089-1093.
30. Lacoursiere E, Vaillancourt G, Couture R. Relation entre les plantes aquatiques et les Gastéropodes (Mollusca: Gastropoda) dans la région de la Centrale Nucléaire de Gentilly I (Quèbec). Canadian Journal of Zoology. 1975; 53:1868-1874.
31. Vincent B, Lafontaine N, Caron P. Facteurs influencant la structure des Groupements de Macroinvertébrés benthiques et phytophiles dans la zone littorale du Saint-Laurent (Québec). Hydrobiology. 1982; 97:63-73.
32. Brackenbury TD, Appleton C C. Effect of controlled temperatures on gametogenesis in the gastropods *Physa acuta* (Physidae) and *Bulinus tropicus* (Planorbidae). The Journal of Molluscan Studies. 1991; 57:461–469.
33. Malone JB, Loyacano AF, Hugh-Jones ME, Corkum KC. A three-year study on seasonal transmission and control of *Fasciola hepatica* of cattle in Louisiana. Preventive Veterinary Medicine. 1984; 3:131-141.
34. Dillon RT. The ecology of freshwater molluscs. Cambridge: Cambridge University Press. 2004, 499.
35. Aziz MA, Raut SK. Thermal effect on the life-cycle parameters of the medically important freshwater snail species *Lymnaea* (Radix) *luteola* (Lamarck). Memórias do Instituto Oswaldo, Rio de Janerio. 1996; 91:119-127.
36. Hadderingh R H, Van D VG, Schnabel PG. The effect of heated effluent on the occurrence and the reproduction of the freshwater limpets *Ancylus fluviatilis* (Müller, 1774), *Ferrissia wautieri* (Mirolli, 1960) and *Acroloxus lacustris* (L., 1758) in two Dutch water bodies. Hydrological Bulletin. 1987; 21:193–205.