1. INTRODUCTION

1.1. Country Background

Nepal, the Himalayan country with the tallest mountain range in the world, is situated between the latitudes $26^0$22'N and $30^0$27'N and longitudes $80^0$04'E and $88^0$12'E. It is bordered by Tibet, China in the north and India in east, south and west. It has a total area of 147,181 square km extending approximately 885 km from east to west and 140 to 280 km from north to south. Within its short span, Nepal represents five unique geographical zones: 1. Terai, 2. Siwalik or Churia hill, 3. Mahabharat, 4. Midland and 5. Higher Himalayas. Each zone is characterized by unique geography, climate, culture, flora and fauna (Sharma 1973).

Terai is about 30-40 km wide low land, extending 800km east-west direction border with India. Fertile land is characterized by old and new alluvial deposit, where 48% people live here.

Churia Hills (Siwaliks) rise abruptly to an average altitude of 1300m while elevation is from 700 to 1500m. It is narrow in east and wider in west and far west. Churia hills composed of sedimentary rock of Oligocene to Pleistocene age so that fossil record of big animal can be finding.

Mahabharat Range extends within an elevation ranges of 1500 to 2700m. It is well developed in eastern and central regions than western and far western regions. It controls rainfall and temperature of midland and Himalayas of North. Mid land is 50 to 100 km wide. Its average altitude is 2000 m while elevation is 600 m to 3000 m. It is characterized by temperate climate. There are highly populated valleys in this range like Pokhara, Kathmandu, Banepa and Trisuli.

Higher Himalayas lies in northern part of country. It is about 45 km wide in north-south direction where 200 peaks are of more than 7000 m altitude. Topography is smooth where Glacier Lake culminates. Most areas have canyons, steep cliffs and hanging valley condition. There are several inner Himalayan valleys with desert condition viz. Mustang and Mugu valleys with more than 3,600 m altitude.

There is a wide range of climate representing sweating heat of Terai to freezing cold of higher Himalayas but Mahabharat and Mid hills are moderate. The climate is primarily influenced by monsoon begins from Bay of Bengal. Basically, climate of Nepal is divided into dry period of winter and wet period of summer

Precipitation plays an important role in determining climate which ultimately affects the vegetation pattern. Heaviest rainfall is brought about by south-west but with east monsoon originating from Bay of Bengal. First reaches eastern part of Nepal and then gradually decreases moving from east to westward but increases from plain to certain altitude. The average precipitation in Nepal is about 1015 mm but with uneven distribution of rainfall. Thus, altitude, climate and soil type produce various phyto-geographical divisions representing 1. Tropical and sub tropical zone 2. Temperate zone and 3. Sub alpine and alpine zone.

Biogeographically, Nepal Himalaya is a transitional zone between Palaeartic and Indo-Malayan realms with species from both contributing to its biodiversity. Thus Nepal is rich in terms of biodiversity species richness. Although Nepal shares only 0.9% of global land mass, it harbors about 2.7% of flowering plant (with 5% endemic species), 5% gymnosperm, 3% of pteridophytes and 5% of bryophytes. Similarly, its faunal diversity comprises mammals (4.52%), birds (9.3%), amphibians (1.2%), reptiles (2.03%), butterflies and moths (6.8%) . China, which is 65 times greater in area than Nepal and is home to only 12.5% of worlds mammals, 6.3% of birds, 9.17% of amphibians and 18.8% of reptiles. India is 16 times greater than Nepal share only 8.6% of mammals, 13.3% of birds, 4.3% of amphibians and 7.2% of reptiles of the world (Pie 1996 *cited in* Budha 2005).

Faunal study in Nepal was limited to mammals and birds before 1950s. Taxonomic works for the Nepalese invertebrate fauna begin only after 1950 when country was allowed to foreigners. Many scientists, majority of them were entomologists from different countries like England, Japan, Germany, India and USA visited Nepal and thousands of papers published in international journals. Thapa (1997, 1998) listed most of the previous reports and new descriptions of insects from Nepal. According to his report, approximately 5,052 insects were known from Nepal with description of 60 genera and 1,131 species from Nepalese specimens. This data is more than a decade old and this number may increases few folds because there are several new additions and description of new species from Nepal every year.

1.2. Mollusk and its importance

Mollusks are second largest group in animal Kingdom in term of species diversity after arthropods. Among other invertebrates, mollusk are best known groups in world (Budha, 2005). They colonized wide range of habitats on land, freshwater, sea and some are adapted to arboreal habitats. They are distributed throughout the world from Seawater up to depth of 11,020 to above 4500 m height in the Himalayas (Budha, 2007). A total of 200,000 species have been estimated to be found in the world with small fraction of terrestrial (40,000 species) and freshwater (10,000 species) but only 24,000 and 7,000 species of terrestrial and freshwater mollusk species have been identified (Lydeard et al. 2004). The terrestrial species are mostly ground dwellers found under stone, fallen leaves, crack, wooden log and in cervices. Primarily, they are detrivores feeding on dead and decayed plant material and few are carnivores. Some specific feeder directly contributing in food web by recycling nutrient to stabilize community structure and function. Freshwater and terrestrial snails are used as ecological indicator species (Godan 1983) because many species have narrow range of ecological tolerance, have limited mobility, restricted to particular habitats.

Mollusk occupied important position in human civilization. They are important in medical and veterinary science because snails act as intermediate host of certain parasites. Nowadays, they are used in scientific research, as in study of drug action, using mollusk heart, hormone, enzyme and antitoxin in relation to immunological hematology; shells are used in study of process of calcification of bone. Gastropods play important role in balancing natural ecosystem by producing humus, disposing plants and animals waste and also acting as predator and parasite (Gordan 1983).

Himalaya is an important place for studying terrestrial snails and slugs due to high rate of endemism. There are 94.6% of endemic terrestrial gastropods confined to eastern and central Himalayas (Dey and Mitra 2000). But Nepal Himalaya which is centrally located in the entire Himalayan range is poorly studied. The study of mollusk is shockingly poor due to difficulties in identification, lack of manpower, research

infrastructure and logistic support for the researcher (Budha 2005). The present study will find some gastropod faunal assemblages and diversity pattern in central mid hills to generate faunal information of these poorly studied animals.

2. OBJECTIVES

The main objective of this research is to explore terrestrial gastropod fauna and their distribution in the Nagarjuna Forest.

Specific objectives are to:

1. identify land snail fauna of Nagarjun forest,
2. prepare identification keys to terrestrial snails of the study area,
3. estimate abundance of land snails species found in Nagarjun forest
4. find land snails distribution pattern in relation to altitude and pH.

2.1 Rational of the study

Mollusks are one of the most threatened groups of animals. There are 1,222 species of terrestrial and 706 species of freshwater mollusk have been kept in IUCN red list (Lydeard et al. 2004) for their conservation. But Nepal is poorly investigated and many species are under extinction before their identification. Recently Budha et al. (2010) assessed freshwater molluscs of eastern Himalaya and listed two species (*Lymnaea ovalior* and *Tricula mahadevensis*) as Vulnerable and one species (*Sphaerium austeni)* as Near Threatened species.

The Kathmandu valley is important place to study malacofauna because there are many endemic species such as *Himalodiscus aculeatus*, *Hemiphaedusa kathmandica*, *Nepaliena ceratina*, *Anadenus nepalensis* and *Bensonies nepalensis* (Kuznetsov 1996; Nordsieck 1973; Schileyko and Frank 1994 and Wiktor 2001). But only few studies were carried out in the Nagarjun forests primarily on flora (Kanai and Shakya 1970), bats (Malla 2000) but information on most of the invertebrate fauna is severely lacking. The present work will document terrestrial gastropod fauna to fill the gap of information.

2.2 Limitation of study

The present work does not cover the entire forest area due to time limitation, accessibility, field security and financial constraints. The survey area is restricted in the Balaju-Jamacho trekking route only. Thus this study does not represent the entire Nagarjun forest area.

3. LITERATURE REVIEW

Mollusks from Indian Subcontinent were well studied by British malacologists from 1830 to 1900s. The most of the described species of terrestrial mollusks from Indian subcontinents were included in three volumes of 'Fauna of British India' (Blanford and Godwin–Austin 1908; Gude 1914, 1921). Although all information in these volumes are outdated in current taxonomy, these are still primary source of information for the region to researchers. There are only few Indian malacologists who published papers on species distribution in different parts of Indian (Dey et *al.* 1985, 2003, Dey and Mitra 2000, Mitra and Dey 1990, 1992, Rao et al. 1995, Mookherjee et al. 2000, and Thakur et al. 1992) are primarily based on the past studies and there are rarely any new species descriptions noted after British colonial period in Indian part. The previous reports of terrestrial and freshwater mollusk species of eastern Himalayas included India (West Bengal, Sikkim, Assam, Arunachal Pradesh, Mizoram, Nagaland and Meghalaya), Bhutan and Myanmar (Benson1857, Blanford 1865, Godwin-Austen 1916) Likewise, species from western Himalayas included Jammu, Kashmir, Uttaranchal, and Himanchal Pradesh (Nevill 1878, Hutton 1834, and Godwin-Austen 1918). But Nepal had remained untouched from aforementioned pioneer Asian malacologists of 19th century and only had a few known species within Nepal territory. Systematic works on Nepalese snails fauna has begun after Nordsieck (1973) who identified four new species clausillids from Nepal-*Hemiphaedusa kathmandica*, *H. ioes jiriensis*, *H. m. dhaulagirica*, and *H. m. martensiana*.

The most of the taxonomic studies for Nepalese terrestrial mollusks fauna have been done by non-native scientists (Nordsieck 1973, Schileyko and Frank 1994, Kuznetsov and Schileyko 1997, 1999, Schileyko and Kuznetsov 1996, 1998a, 1998b, Wiktor 2001, Bössneck 2006 and Gerber and Bössneck 2009). There are only few Nepalese scientists who published papers on terrestrial molluscks (Subba and Ghosh 2000, 2001, 2008,

Subba 2003, Budha 2005, 2007, Thapa 2003, Budha and Naggs 2008). All their works indicate that there is a need for extensive surveys of malacofauna in Nepal. According to Budha (2005) there are more than 139(83 terrestrial and 56 freshwater mollusk) have been reported so far from Nepal. There are some occasional papers on teresstrial and freshwater molluscs of Nepal covering most of the five developmental regions (Subba and Ghosh 2000, 2001, 2008, Subba, 2003 and Thapa 2003) but reported very low number of species. They reported terrestrial mollusks representing 15 genera and 15 species and freshwater mollusk representing 12 genera and 25 species.

Subba Rao (1989) reported 285 species of freshwater mollusks from India, Pakistan, Bangladesh, Myanmar, Srilanka and other adjoining countries. He added number of new species, excellent information on biology, bionomics and distribution. He has given key to families and genera. His study mainly based on morphological features and their habitat preference but not anatomical investigation. Nesemann et al. (2007) reported 108 species of freshwater (49 Bivalvia and 59 Gastropods mollusks) from Ganga River system and other adjoining water bodies. Out of them there are 61 species (29 Bivalvia and 32 Gastropods) were reported from Nepal. Bivalves were represented by three families were Sphaeridae, Unoidae and Amblemidae and Gastropodes were represented by 11 families were Bithyniidae, Pomatiopsidae, Thiaridae, Pleuroceridae, Viviparidae, Ampullariidae, Lymnaeidae, Planorbidae, Physidae, Succineidae, and Carychiidae.

3.1 Distribution of Nepalese Terrestrial Mollusk

On the basis of the best available literature there are 100 terrestrial snails and slug species (Appendix 2) reported from Nepal belonging to 42 genera and 24 families. The present species diversity includes Western Development Region occupying 54 percent of the total species reported from Nepal followed by EDR 32 %, CDR 29 %,, FWDR 8 % and MWDR 7 (Table 1).

Table 1. Terrestrial mollusks reported from Nepal

	Nepal	EDR	CDR	WDR	MWDR	FWDR

Family	24	14	14	18	4	5
		(58.33)	(58.33)	(75)	(16.67)	(20.83)
Genus	42	18	23	26	4	4
		(42.85)	(54.76)	(61.90)	(9.52)	(9.52)
Species	100	32	29	54	7	8
		(32)	(29)	(54)	(7)	(8)
Altitude (in m.)	70-5000	70-1700	1300-4835	1100- 4900	2600-4900	2000-5000

Source: Nordsieck 1973, Schileyko and Frank 1994, Kuznetsov and Schileyko 1996, 1997, 1998,Subba and Ghosh 2000, 2001, 2008, Wiktor 2001, Wiktor and Bössneck 2004, Kuzminykh and Schileyko 2005, Bössneck 2006, Budha and Naggs 2008, Gerber and Bössneck 2009.

Note = EDR- Eastern Development Region, CDR- Central Development Region, WDR- Western Development Region, MWDR- Mid-western Development Region, FWDR- Far-western Development Region. Number in parenthesis represents percentage.

3.1.1 Eastern Nepal

Mollusk species collected by occasional visitors from most of the districts of the eastern part of Nepal were included Ilam, Pachthar, Taplejung, Sunsari, Dharan, Terhdhum, Morang, Sunsari, Dhankuta and Udhayapur (Kuznetsov and Schileyko 1997, 1998, Subba and Ghosh 2001, Bössneck 2006, Kuzminykh and Schileyko 2005, Subba and Ghosh 2008 and Gerber and Bössneck 2009). Mechi and Sagarmatha zone harbor unique and interesting faunal diversity as many species have been reported from this region. Subba and Ghosh have done study almost whole district of Mechi zone and other lower Terai of eastern region. Three species of micro-snails (*Vallonia costohimala, V. himalaevis* and terrestrial slug *Anadenus (Sagarmathia) kuznetsovi* are new to science from the region. The species diversity of the Eastern Development Region are given in Table 2.

Table 2. Terrestrial mollusks of Eastern Development Region (EDR), Nepal

Subclass: Order/Family	Genus	Species	Reference
Prosobranchia: Caenogastropoda			
Cyclophoridae	2	5	Kuznetsov and Schileyko 1997
Diplommatinidae	1	4	Kuznetsov and Schileyko 1997
Pulmonata: Styllomatophora			
Ariophantidae	4	5	Subba and Ghosh 2001
Agriolimacidae	1	1	Bössneck 2006
Achantinidae	1	1	Budha and Naggs 2008
Vallonidae	1	3	Gerber and Bossneck 2009
Veronicellidae	1	1	Subba and Ghosh 2008
Glessullidae	1	1	Subba and Ghosh 2008
Helliocarionidae	1	1	Subba and Ghosh 2008
Anadenidae	1	1	Kuzminykh and Schileyko 2005
Ellobiidae	1	1	Kuznetsov and schileyko 1997
Camaenidae	1	2	Schileyko and Kuznetsov 1998
Enidae	1	1	Kuznetsov and Schileyko 1997
Subilinidae	2	1	Subba and Ghosh 2008

Kuznetsov and Schileyko (1997, 1998) Reported *Mirus (?) nilagirius, Landouria oborensis, L. coeni, Alycaeus burti, Chamalycaeus (C.) summus, C. (Dicharx) notatus, Diplommatina (D) oviformis,* and *D. pachychilus. D. separata, D (Sinica) canarica* and *Carychium minusculum* from Solulkhumbu district from 1750 to 2840 m-elevation.

Subba and Ghosh (2001) reported *Cyclophorus fulguratus, Macrochlamys indica* and *M. tugurium, Khasiella pansa, Bensonies nepalensis* from several eastern districts. Budha and Naggs (2008) reported distribution pattern of invasive land snails African Giant Land Snail (*Lissachantina fulica*) and its dispersal from east to west of Nepal.

Three slug species *Deroceras laevae, Leavicaulis cf altae* and *Anadenus (Sagarmathia) kuznetsovi* were reported from eastern Nepal (Subba and Ghosh 2008, Bössneck 2006 and Kuzminykh and Schileyko 2005).

Subba and Ghosh (2008) reported *Glessula tenuispira*, *Cryptaustenia ovate*, *Macrochlamys lubrica*, *Opeas* sp, *Taphrospira compluvialis, Bacillum* sp, *Rotungia williamsoni* from Ilam, Pachthar, Taplejung, Sunsari, Dharan, Terhdhum, Kailali and Kanchanpur district. But *Glessula tenuispira* and *Rotungia willimasoni* were misidentified because the previous species belong to Rishetia and later species is under *Landouria*. Similarly identification of *Bacillum* sp. is also doubtful.

3.1.2 Central Nepal

Reports on the land snails from Central Nepal includes Kathmandu, Lalitpur, Rasuwa, Dolakha, Ramechap and Chitwan districts (Nordsieck 1973, Schileyko and Frank 1994, Kuznetsov and Schileyko 1996, Kuznetsov 1996, Bössneck 2006, Kuznetsov and Schileyko 1998, Subba and Ghosh 2001, Wiktor 2001, Gerber and Bössneck 2009). Reported species from Central Development Region are given in Table 3.

Table 3. Terrestrial mollusks of Central Development Region (CDR), Nepal

Subclass: Order/Family	Genus	Species	Reference
Prosobranchia: Caenogastropoda			
Cyclophoridae	2	3	Kuznetsovand Schileyko 1996
Diplommatinidae	1	1	Kuznetsovand Schileyko 1997
Pulmonata: Styllomatophora			
Ariophantidae	6	10	Kuznetsov and Schileyko 1996, Subba and Ghosh 2001
Agriolimacidae	1	1	Bössneck 2006, Wiktor and Bössneck 2004
Achantinidae	1	1	Budha and Nagg 2008
Vallonidae	2	5	Gerber and Bössneck 2009
Veronicellidae	1	1	Subba and Ghosh 2008
Glessullidae	1	1	Kuznetsov and Schileyko 1996
Anadenidae	1	2	Wiktor 2001
Philomycidae	1	1	Bössneck, 2005

Camaenidae	1	2	Schileyko and Kuznetsov 1998
Enidae	1	1	Schileyko and Frank 1994
Clausillidae	1	2	Nordsieck 1973
Plectopylidae	1	1	Kuznetsov and Schileyko 1996

Nordsieck (1973) described new Clausilid *Hemiphadusa kathmandica* from Phulchowki hill and *H. ioes jiriensis* from Jiri. Other new descriptions of the snails from the region were *Himalodiscus aculeatus, Vallonia kathrinae, V. costohimala* (Kuznetsov and Schileyko 1996, Wiktor 2001 and Gerber and Bössneck 2009). Other snails include *Chamalyceus (Cyclorix) otiphorus, C.(Dicharax) bicrenatus, Alyceus (A) lohitensis, Diplommatina* sp., *Khasiella ornatissima, Macrochlamys nuda, M. patane, Euaustenia monticola, Glessula subjerdoni, Plectopylis minor, Laevozebrinus nepalensis, Oxytesta orobia, Euaustenia monticola, Landouria savadiensis, L. aborensis* and *Nepaliena ceratina* (Schileyko and Frank 1994, Kuznetsov and Schileyko 1996, 1997, 1998).

The slug species of the region includes *Anadenus nepalensis, Meghimatium cf pictium Deroceras lavae, Laevicaulis* cf *alte* (Bössneck 2005, Wiktor 2001).

Subba and Ghosh (2001) reported *Machrochlamys indica, M. tugurium* and *Bensonies nepalensis, Oxytes sylvicola* from Kathmandu at elevation ranges from Churia to Mahabharata range.

3.1.3 Western Nepal

Literature review reveals that this region accommodates high species diversity in comparison to other regions. Studies were done on mostly in Dhaulagiri and Gandaki zone and Lumbini remained unexplored. Taxonomic works on the mollusk have been contributed by Nordsieck 1973, Schileyko and Frank 1994, Kuznetsov and Schileyko 1997, 1999, Subba and Ghosh 2001, Wiktor 2001, and Gerbes and Bössneck 2009. Endemic land snails of Nepal from this region include *Pupinidius tukuchensis, Laevozebrinus mustangensis, Laevozebrinus nepalensis myagdiensis, Bradybaena (?) thakkholensis, Himaldiscus echinatus, Pupinidius siniayevi, Landouria dhaulagirica, L. rhododendronis* including two sub species *Hemiphedusa .m. martensiana, H. m. dhaulagirica.* Species diversity of land snails and slugs of WDR is given in the Table 4.

Table 4: Terrestrial mollusks of Western Development Region (WDR), Nepal

Subclass/ Order/Family	Genus	Species	Reference
Prosobranchia: Caenogastropoda			
Cyclophoridae	1	2	Kuznetsov and Schileyko 1996
Pulmonata: Styllomatophora			
Ariophantidae	6	15	Kuznetsov and Schileyko 1996, Subba and Ghosh 2001
Achantinidae	1	1	Budha and Nagg 2008
Vallonidae	1	4	Gerber and Bössneck 2009
Pupillinidae	1	2	Schileyko and Frank 1994
Anadenidae	1	2	Wiktor 2001
Camaenidae	1	3	Kuznetsov and Schileyko 1998
Enidae	2	6	Kuznetsov and Schileyko 1997
Clausillidae	1	3	Noedsiek 1973
Plectopylidae	1	1	Kuznetsov and Schileyko 1996
Bradybaenidae	1	2	Kuznetsov and Schileyko 1998
Heliocarionidae	2	5	Schileyko and Frank 1994
Euconulidae	1	1	Kuznetsov and Schileyko 1997
Streptaxidae	1	1	Kuznetsov and Schileyko 1997

Pyramidulidae	1	1	Kuznetsov and Schileyko 1997
Vertiginidae	1	1	Kuznetsov and Schileyko 1997
Vitrinidae	1	-	Kuznetsov and Schileyko 1997
Subulinidae	2	-	Schileyko and Frank 1994

Nordsieck (1973) described two new sub species *Hemiphedusa m. martensiana* and *H. m. dhaulagirica* from Dhorpatan and Jaljala within elevation range of 2300-2900 m above sea level.

Schileyko and Frank (1994) reported *Allopeas mauritianus prestoni, Bensonies convexus, Cryptaustenia ovata, C. cf globosa, Cryptaustenia* sp., *Cyclophorus pyrotrema, Endothyrella ex. gr. affinis Laevozebrinus nepalensis nepalensis, L. nepalensis myagdiensis, Landouria huttoni, Macrochlamus longicauda, M. subjecta* from Annapurna Conservation area. Other species reported from this area were *Bradybaena radicicola, B. (?) thakkholensis, Bensonies convexus, Euaustenia monticola, Euconulus fulvus, Gastrocopta huttoniana, Hawaia* sp, *Himalodiscus echinatus, Landouria* sp., *Kaliella barrakporensis, Laevozebrinus mustangensis, Macrochlamys sequax, M. sequis, M. lata (?), M. longicauda, M. subjecta, Oxytesta blanfordi, O. orobia, Pupinidius tukunchensis, Pupilla eurina, P. triplicata, Pyramidula humilis, Syama prona, Truncatellina* sp. and *Vallonia ladacensis* (Kuznetsov and Schileyko 1997, 1998).

3.1.4 Mid –Western Nepal

Only few district namely Humla, Jumla, Dolpa of Karnali and Banke of Bheri and Dang of Rapti zones were surveyed. Only few papers include the malacofauna of this region by (Wiktor 2001,Bössneck 2006, Subba and Ghosh 2008,Gerber and Bössneck 2009). The known species from this regions include *Anadenus nepalensis, Macrochlamys lubrica Laevicaulis cf alte, Vallonia costhimala, V. kathrinae* and *V. himalayaevis*. The species diversity of terrestrial snails and slugs are given in Table 5.

Table 5. Terrestrial mollusks of Mid-Western Development Region (MWDR), Nepal

Subclass/Order/Family	Genus	Species	Reference
Pulmonata: Styllomatophora			
Ariophantidae	1	1	Subba and Ghosh 2008
Vallonidae	1	3	Gerber and Bössneck 2009
Veronicellidae	1	1	Subba and Ghosh 2008
Anadenidae	1	1	Wiktor 2001

3.1.5 Far-western Nepal

There is only scarce information available on mollusks fauna of Bajura, Darchula Kailali, Kanchanpur districts of FWDR (Wiktor and Bössneck 2004, Bössneck 2006, Subba and Ghosh 2008, Gerbes and Bössneck 2009). Only eight species representing 5 families indicate have been known till date from the region. New species of slug *Limax seticus* was reported from Bajura District above 5000 m (Wiktor and Bössneck 2004). It is probably, highest record in the world for any slug species. The current species reported in this regions are given in the Table 6.

Table 6.Terrestrial mollusks of Far-Western Development Region (FWDR), Nepal

Subclass/order/family	Genus	species	reference
Pulmonata: Styllomatophora			

Ariophantidae	2	2	Subba, 2003, Subba and Ghosh 2008
Vallonidae	1	2	Gerber and Bössneck 2009
Veronicellidae	1	1	Subba and Ghosh 2008
Limacidae	1	1	Wiktor and Bössneck 2004
Anadenidae	1	1	Wiktor 2001

The known species from FWDR are *Anadenus altivagus, Khasiella pansa, Macrochlamys lubrica, Laevicaulis cf alte, Limax seticus, Vallonia himalaevis,* and *V. ladacensis.*

4. METHOD AND METHODOLOGY

4.1 Description of Study Area

Present study is conducted in Nagarjun forest (27˚43′37.13" to 27˚46′22.84N and 85˚13′52.97" to 85˚18′43.38"E) in northernmost boarder of Kathmandu valley. This forest was small fragmentary hill while collecting sample but now, it is merged with Shivapuri national park and declared as Sivapuri-Nagarjun national park to conserve flora and fauna in large scale.

Nagarjun forest occupies an area of 16.45km at boarder of Kathmandu and Nuwakot district. The main range of the hill runs in east-west direction with its highest peak Jammacho (2,188 m) which rises abruptly from floor of Kathmandu valley (1,300 m). It has taken into official protection programmed in 1971 (DFO office Nagarjun, per. com.) by HMG Nepal. After that infrastructure development, proceed with main objective of achieving effective protection against deforestation and further loss of wild fauna. A 29 km fence wall and 31 km of motorable road up to Jammacho has been constructed.

4.2 Climate of Study Area

Nagarjun forest is a typical Mahabharata hill and enjoys mostly tropical type of climate and partly temperate climate (Chaudhary 1998) with rainy summer and dry winter. The southern side is sunny and is evidently much drier than northern-forested side. As the climate, data of Nagarjun is not available. The climatic data of nearest meteorological station of Budhanilakhantha are used. Temperature and humidity data are available from 1999 to 2008 but precipitation data is not available. Average monthly maximum temperature was 27.26 at August and average monthly minimum temperature was 3.24 in January. Likewise, average monthly maximum relative humidity was 91.5% at December and Average monthly minimum relative humidity was 64.4% at March(Figure1)

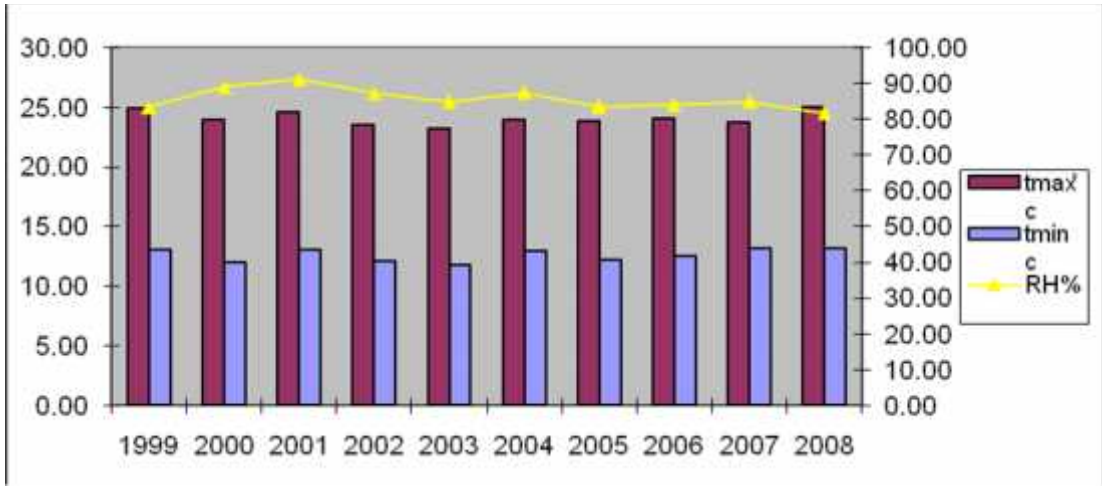

Figure: 1 The average maximum and minimum temperature and Humidity, Budhanilkhantha station, Meteorology and Hydrology Department.

4.3 Fauna

Shivapuri Nagarjun NP support faunal diversity with number of protected species. There are 21 species of mammals, 311 species of birds, 102 species of butterflies including a Relict Himalayan Dragonfly (*Epiophlebia laidlaw*i), Wild Boar (*Sus scrofa),* Barking Deer (*Muntiacus muntjak),* Rhesus Monkey (*Macaca mulatta),* Porcupine (*Hytrix indica),* Goral (*Naemorhedus goral),* Pangolin (*Manis* spp)., Clouded Leopard (*Pardofelis nebulosa)* and Jungle Cat (*Felis chaus)* (DNPWC 2009).

4.4 Flora

Flora of Nagarjun has been documented by Kanai and Shakya (1970). They categorized into 4 types of forest such as Schima wallichi forest, mixed broad leaved forest, pine forest and dry oak forest and few small patches of grass meadows.

1. **Schima wallichi:** It is found up to nearly 1800 m altitude. This forest includes *Schima wallichi* (Dominant), *Myrsine semiserrata, Castanopsis indica, Castanopsis tribuloids, Ligustrum nepalensis, Phoebe lanceolata, Quercus spicata* and other shrubs are *Sarcococca coriacea, Smilax aspera, Arundinaria falcate* and *Desmodium oxyphyllum* etc.
2. **Mixed broad leaved forest**: It is stretched between 1800 m and 2000 m elevation including *Phoebe lanceolata, Machilus duthiei, Michelia kisopa, Acer oblongum, Quercus glauca* tree species. The common shrubs include *Camellia kissi, Caryopteris grata, Docecademia grandiflora* and *Sarcocca hookeriana*.
3. **Pine forest**: Pine forest was found in patches at low altitude mostly in southern slope in Raniban, Ichangu and Aindada. *Pinus roxburghii* was dominant trees associated with other small trees of *Myrica esculenta, Schima wallichi* and shrub like *Sarcococca coriacea, Berberis asiatica, Myrsine semiserrata* and *Robus ellipticus* etc.
4. **Dry oak forest**: It was found to occur at steep rocky and exposed southern and northern slope of ridge at an altitude of 2,000-2,188m on south, west and east while 2050-2188m in north. *Quercus lanuginose* was dominant component with few trees of *Lyonia ovalifolia, Rhododendron arborium* and common shrub like *Berberis asiatica, Cariopteris grana* and *Rubus ellipticus* etc.

4.5 Data Collection

The primary data were collected by visiting the study sites from December 2008 to March 2009. The secondary data were collected from published papers and books.

4.5.1 Field sampling

The forest area was searched in 10x10 m random plots and 1x1m subplot within a main plot along the trekking route of Balaju-Jamacho. The sampling plot was modified from Tattersfield (1996). Altogether 21 plots were sampled. Potential microhabitat such as leaf litter, base of tree, tree trunk, foliage, fallen logs and stone, mosses etc were carefully searched within a plot. Each plot includes 10x10m size and two subplot of 1x1m within each plot was examined thoroughly for 15 minutes per/plot by 4 individuals. Larger shell was easily noticed and picked up by hand or forceps and were kept in zip locked plastic bag and vials depending on the size and shape. But for smaller form and leaf litter including surface soil was collected in the polythene bag. The leaf litter including other unwanted substance must be scraped off. For this purpose, the soil was spread over the paper sheet to air dry and passed through a coarse (4mm mesh size) to medium (0.5mm mesh size) sieve after drying up in the sunlight/shed. Large species retain in the sieve will be removed and fine sieve fractions will be sorted out under good illumination, until no further mollusks could be found. Beatings of the above ground vegetation in an inverted umbrella were done to sample unseen mollusks above the ground in each plot. Mostly micro snails were collected by beating technique. Microsnails are of minute size and delicate and shiny. Hence, they were collected by minute forceps under good illumination. Sieved soil will be brought to the laboratory for PH Physical plots characteristics like Topography, inclination, aspect,vegetation and forest type including altitude were recorded in mollusk inventory form for descriptive analysis of collected specimens. Abundance and species richness depend on the above mentioned factors.

4.5.2 Sorting sample

The entire collecting samples were separated in the shell and live animals and kept separately either in plastic vial or zip locked plastic bag with label of the representing microhabitats, location, date and collectors name. Live animals were kept in 70 percent alcohol which will be replaced one to two times within a week depending upon the number of live specimens and brought to the central department of Zoology Tribhuvan University, Kirtipur, Kathmandu, Nepal for the detail anatomical investigation.

4.6 Laboratory work

Shell and animal morphology was studied. Shape and size of Shell, presence/absence of varied shape, sculpture on the shell surface, structure of the embryonic whorls, shape of loop and umbilicus will be carefully studied. Likewise color of the body, presence/absence of mantle lobes and mucous pore, structure of the foot will be noted at the laboratory. Animal will be dissected for the reproductive organs and sketched by using camera Lucida for species level confirmation.

4.7 Data Analysis

Species lists were determined for each sample plot and study site. Data were analyzed in descriptive way for the taxonomy work. But the relationship between mollusk diversity against altitude and soil pH was explored by using correlation analysis. Species diversity was calculated using Shannon winner's diversity index and analytical characters such as frequency and density are expressed quantitatively as well as qualitatively. The distribution pattern of land snails was also determined by using x^2-test. Thus, these characters of each species were calculated which are as follows.

Species diversity: To determine relative abundance of individual species, the species diversity method was applied. Species diversity based on relationship between total no of species and individual species. Species diversity is useful for investigating interaction between physical and biotic factor in an ecosystem. Species diversity of individual species was calculated by using the following formula.

$$Shannon\ index\ \bar{H} = -\sum p_i \log_8 p_i$$

$$evenness(e) = \frac{\bar{H}}{\log s}$$

Frequency and relative frequency:-The frequency of a species is the measure of chance of finding it with any one quadrate in given area. In general, frequency is useful measure of abundance where comparison is made on large scale. Relative frequency is the dispersion of one species in relation to total species. The working formulas are as follows.

$$frequency = \frac{no\ of\ plots\ in\ which\ species\ occured}{total\ no\ of\ plots\ studied} \times 100\%$$

$$Relative\ frequency = \frac{frequency\ of\ a\ species}{sum\ of\ frequency\ of\ all\ species} x100\%$$

Density: Density represents numerical strength of species in the community. The no of individuals of the species in any unit area is density. Relative density is the proportion of total number of individual of a species with total no of individuals of all species within an area. Density gives the idea of degree of competition. It was calculated as

$$Density = \frac{Total\ no\ of\ individuals\ of\ the\ species\ in\ all\ smpling\ units}{Total\ no\ of\ sampling\ \ units\ studied}$$

5. RESULTS

5.1. Land snail collected from Nagarjun Forest.

A total of 1140 specimens representing 2 order, 12 families, 21 Genera and 39 species were recorded from Nagarjun Forest (Appendix 1). Details are given below;

Class - Gastropoda

Subclass - Prosobranchia

Order- Caenogastropoda

Family -Cyclophoridae

Genus *Theobaldius* G. Nevill, 1878

1. *Theobaldius phaenotopicus* (Benson, 1851) Plate 1 fig(4)

   Total number of specimens =7 [1.I.2009 (5), 24 .I.2009 (2)]

Genus *Alycaeus* Gray, 1850

2. *Alycaeus burti* Godwin-Austen, 1974 Plate 1 fig(2)

   Total number of Specimens =194[4 I.2009 (130), 16.I. 2009 (20), 12.III.2009 (20), 24.iii.2009 (24)]

3. *Alycaeus plectochilus* Benson, 1859

   Total number of specimens=90[30.XII.2008(7), 16.I.2009 (9) ,12.I.2009 (66) 24.I.2009 (8)]

4. *Alycaeus cf burti*

   Total number of specimens=16[4.I.2009 (8),12.I.2009(5),16.I.2009(3)

5. *Alycaeus cf inflatus* Godwin-Austen, 1874

   Total number of specimens=1[30.XII.2008 (1)]

6. *Alycaeus cf bicrenatus* Godwin-Austen, 1874

   Total number of specimens**=**2[12.I.2009 (1), 16.I.2009 (1)]

7. *Chamalycaeus (Dicharax)* sp1 Plate fig(3)

   Total number of specimens =135**[**4.I.2009 (32), 12.I.2009(20), 12.I.2009 (20), 12.I.2009 (65)]

8. *Chamalycaeus (D.) digitatus* Plate 1 fig(1)

   Total number of specimens=4 **[**4.I.2009 (3), 12.I.2009 (1)]

   Genus *Cyclophorus* Montfort, 1810

9. *Cyclophorus* sp.

   Total number of specimens=1**[**24.I.2009 (1)]

   Family: Diplommatinidae

   Genus *Diplommatina* Benson, 1849

10. *Dipolmmatina* sp.1

    Total number of specimens =18**[**24.I.2009 (3), 24.I.2009 (4), 12.III.2009 (11)]

11. *Diplommatina* sp.*2*

Total number of specimens=15**[**24.I.2009 (2), 12.III.2009 (13)]

12. *Diplommmatina folliculus* Benson, 1849 Plate 1 fig(6)

    Total number of specimens=3**[**24.I.2009 (2), 24.III.2009 (1)]

    Subclass: Pulmonata

    Order: Stylommatophora

    Family: Pyramidulidae

    Genus *Pyramidula* Fitzinger, 1833

13. *Pyramidula humilis* Pilsbry, 1893

    Total number of specimens=1**[**12.I.2009 (1)]

    F**amily: Clausilidae**

    Genus *Hemiphedusa* O. Boettgor, 1877

14. *Hemiphedusa* sp Plate 1 fig(8)

    Total number of specimens=5**[**24.I.2009 (5)]

    Family: Subulinidae

    Genus *Allopeas* H.B.Baker, 1935

15. *Allopeas* sp Plate 1fig(7)

Total number of specimens=47**[**30.XII.2008 (8), 4.I.2009 (16), 12.I.2009 (8), 16.I.2009 (15)

Family: Plectopylidae

Genus *Plectopylis* Benson, 1860

16. *Plectopylis minor* Godwin-Austen, 1979 Plate 1 fig(12)

Total number of specimens=136**[**30.XII.2008 (117), 4.I.2009 (18), 24.I.2009 (1)]

Family: Heliocarionidae

Genus *Kaliella* Blanford, 1863

17. *Kaliella barrakporensis* (Pfeiffer, 1852) Plate 2 fig(16)

Total number of specimens=8**[**30.XII.2008 (2), 4.I.2009 (5), 24.I.2009 (1)]

18. *Kaliella fastigiata* (Hutton, 1838)

Total number of specimens =4**[**30.XII.2008 (2), 4.I.2009 (2)]

19. *Kaliella nana* (Hutton, 1838)

Total number of specimens=5**[**4.I.2009 (3), 16.I.2009 (2)]

20. *Kaliella dickrangensis*, Godwin-Austen, 1883

Total number of specimens=3**[**12.I.2009 (1), 16.I.2009 (2)]

Genus *Cryptaustenia* Kockerell, 1898

21. *Cryptaustenia ovata* (H.Blanford, 1871) Plate 2 fig (13)

Total number of specimens=68**[**30.XII.2009 (4), 4.I.2009 (10),12.I.2009 (17), 16.I.2009 (30), 12.III.2009 (4), 24.III.2009 (3)]

Genus *Sitala* H. Adamas, 1865

22. *Sitala* sp Plate 2 fig(15)

Total number of specimens=1**[**12.I.2009 (1)]

Family: Glessulidae

Genus *Reshetia* Godwin-Austen, 1920

23. *Rishetia* sp.A Plate 1 fig(9)

Total number of specimens=29**[**4.I.2009 (15), 12.I.2009 (14)]

24. *Rishetia* sp.B Plate 1 fig(10)

Total number of specimens=2**[**4.I.2009 (2)]

25. *Rishetia longispira* Godwin-Austen, 1920 Plate 1(11)

Total no of specimens=26[30.XII.2008 (11), 4.I.2009 (15)]

Family: Ariophantidae

Genus *Macrochlamys* Benson, 1832

26. *Macrochlamys subjecta*(Benson, 1852) Plate 2 fig (17)

Total number of specimens=8**[**30.XII.2008 (2), 4.I.2009 (1),16.I.2009 (1), 24.I.2009 (1), 12.III.2009 (3)]

27. *Macrochlamys perpaula* (Benson, 1859)

Total number of specimens=56**[**4.I.2009 (5), 12.I.2009 (9),16.I.2009(18),12. III.2009 (15), 24.III.20009 (9)]

28. *Macrochlamys* spA

Total number of specimens=10**[**4.I.2009 (3), 12.I.2009 (3), 16.I.2009 (4)]

29. *Macrochlamys longicauda* Godwin-Austen, 1883

Total number of specimens=5**[**4.I.2009 (2), 12.I.2009 (2) 16.I.2009 (1)

30. *Macrochlamys* spC

Total number of specimens=1**[**16.I.2009 (1)]

31. *Marochlamys* sp.B

Total number of specimens=4**[**4.I.2009(4)]

Genus *Bensonies* H.B Baker, 1938

32. *Bensonies nepalensis* (Nevill, 1878) Plate 2 fig (19)

Total number of specimens=4**[**4.I.2009 (4)]

33. *Bensonies* sp.1 Plate 2 fig (18)

Total number of specimens=156**[**30.I.2008(3), 4.I.2009 (8), 12.I.2009 (27), 16.I.2009 (63), 24.I.2009 (23), 12.III.2009 (3), 24.III.2009 (15)]

Genus *Khasiella* Godwin-Austen, 1899

34. *Khasiella* sp Plate 2 fig (20)

Total number of specimens=14**[**12.I.2009 (8), 16.I.2009 (4), 24.I.2009 (2)]

Genus *Syama* (Nevill, 1878)

35. *Syama prona* (Nevill, 1878) Plate 2 fig (14)

Total number of specimens=5**[**16.I.2009 (2), 24.I.2009 (2), 12.III.2009 (1)]

Family: Camaeinidae

Genus *Ganessella* Blanford, 1863

36. *Ganessela* sp

Total number of specimens=11**[**16.I.2009 (8), 12.III.2009 (3)]

Genus *Landouria* Godwin-Austen, 1918

37. *Landouria savadiensis* (Nevill, 1877) Plate 2 fig (21)

Total number of specimens=31**[**24.I.2009 (17), 24.III.2009 (14)]

Family: Bradybaenidae

Genus: *Bradybaena* Beck, 1837

38. *Bradybaena radicicola* (Benson, 1848) Plate 2 fig (22)

Total number of specimens=1**[**24.I.2009 (1)]

Family: Euconulidae

Genus *Euconulus* Reinhardt, 1883

39. *Euconulus* sp

Total number of specimens=13**[**4.I.2009 (5), 12th.I.2009 (6), 12.III.2009 (1), 24.III.2009 (1)]

5.2 IDENTIFICATION KEY TO SNAILS OF NAGARJUN FOREST

The land snail gastropods (class Gastropoda) collected from Nagarjun forest belong to two subclasses: Prosobranchia (with operculum) and Pulmonata (without operculum). Order Caenogastropoda belongs to the former and the order Stylommatophora belongs to the later subclass respectively. Key to families of both orders are given as;

5.2.1 Keys to families

1. Shell with an operculum …….....(2)

   Shell without an operculum…….....…..... (3)

   2Shell medium to large sized, depressed, broader than high, perforate or umbilicated ….....

   Cyclophoridae

   Shell minute, elongated, higher than broad, plicately striated, narrowly perforated .....….....Diplommatinidae

2. Shell elongate, ovate or Cylindrical, longer than broad….....(4)

   Shell depressed broader than long….....……..... (6)

4. Shell elongate, transversely striated or ribbed, aperture consists folds .....Clausilidae

   Shell ovate, conic-elongated, imperforate, obtuse apex…….…….....…. (5)

5. Shell ovate or elongately turreted, glossy, with or without strong sculpture, collumellar margin truncated ……..….....Glessullidae

Shell elongately turreted, transluscent, with or without sculptures collumellar margin straight…….....Subulinidae

6. Shell minute…….(7)

Shell moderate to large……..……...…….. .....(8)

7. Shell convex, ribbed spiral band, smooth, wide umblicated ……..…..Pyramidulidae

Shell small, shinny, narrow perforate…….…….....….Euconulidae

8. Shell depressed, low spired, more or less flat, widely umblicated…….…….....(9)

Shell depressed, globose or smooth with aperture lunate…….....…..... (10)

9. Shell openly umbilicated, body whorls rounded or carinated, columelar margin often reflected over umbilicus.....…….....Camaeinidae

Shell widely umbilicated with coarse sculpture, last body whorls obstructed by series of denticles inside at some distance from the aperture…….....Plectopylidae

10. Shell globose, perforate, peristome reflected .....….…….Bradybaenidae

Shell depressed, perforate or umbilicated….....……...….....(11)

11. Shell broad than long with many whorls, whorls gradually increasing, with or without sculpture.....Ariophantidae

Shell broader than high, with few and rapidly increasing whorls, aperture wide .....Helicarionidae

5.2.2 Key to Genera

Family: Cyclophoridae

1. Shell conoidly depressed, sutural tube present…….....…(2)

Shell discoid or globose or turbinate, sutural tube absent .....… (3)

2. Shell narrowly umbilicated, aperture circular, pristome thickend and reflexed…….....*Alycaeus*

Shell moderate umbilicated, broader than high…….....*Chamalycaeus*

3. Shell discoid widely umbilicated, last whorls rounded, aperture circular, operculum many whorled .....*Theobaldius*

Shell globosely turbinate, peristome expanded or straight, operculum narrowly coiled….....*Cyclophorus*

Family: Diplommatinidae

Shell minute, transversely plicate, peristome doubled, columellar margin with a entering lamella, ...……..…….*Diplommatina*

Family: Pyramidulidae

Shell openly umbilicated, spirally band, aperture roundly lunate….....*Pyramidula*

Family: Subulinidae

Shell elongate, ovate, narrowly perforate, apex obtuse……..….....*Allopeas*

Family: Clausilidae

Shell sinistral, imperforate, cylindrical ribbed, transversely generally behind the aperture…….…….....*Hemiphedusa*

Family: Helicarionidae

1. Shell depressed, smooth , imperforate, whorls increasing rapidly, last one rounded and large, aperture large……...…….....*Cryptaustenia*

Shell conoidal, thin, trochiform, perforate……...……..... (2)

2. Shell spirally striated ……...….....*Sitala*

Shell finely transeversely striated…….…….....*Kaliella*

Family: Ariophantidae

1. Shell perforate, depressed, transversely sculptured and decussated with fine striation , keeled at periphery, aperture lunate, peristome thin with distinct thickening (callosity) inside….....*Bensonies*

Shell perforate, subdiscoidally depressed, smooth and polished…….……..... (2)

2. Shell brownish tawny above and paler beneath longitudinal striation, last rounded at periphery…….....….....…... *Syama*

Shell smooth or microscopically striated, collumellar margin reflexed at collumellar margin, peristome thin…….....*Macrochlamys*

Family: Camaeinidae

Shell minute turbinate, more or less trochiform, perforate, whorls rapidly increasing, transversely striated .. ..……..*Ganessella*

Shell depressed, broader than long, openly umbilicated, embryonic whorls with scars, last whorls descending infront, peristome thickened….....*Landouria*

Family: Glessulidae

Shell imperforate, ovate-conic, yellowing brown, glossy, without strong sculpture, columellar margin abruptly truncated….....*Glessula*

Shell imperforate, elongately turreted, browninsh, with longitudinal striation…..

……....*Rishetia*

5.3 Diversity of land snails in Nagarjun forest

Altogether 39 species, 20 genera under 2 order and 12 families were identified from Nagarjun forest. Family Ariophantidae included the highest number of species diversity containing 10 species followed by Cyclophoridae, Heliocarionidae, Glessulidae, Diplommatinidae, Camaeinidae. Each of the following families was represented by a single species Pyramidulidae, Clausilidae, Plectopylidae, Subulinidae, Euconilidae and Bradybaenidae (Figure 2).

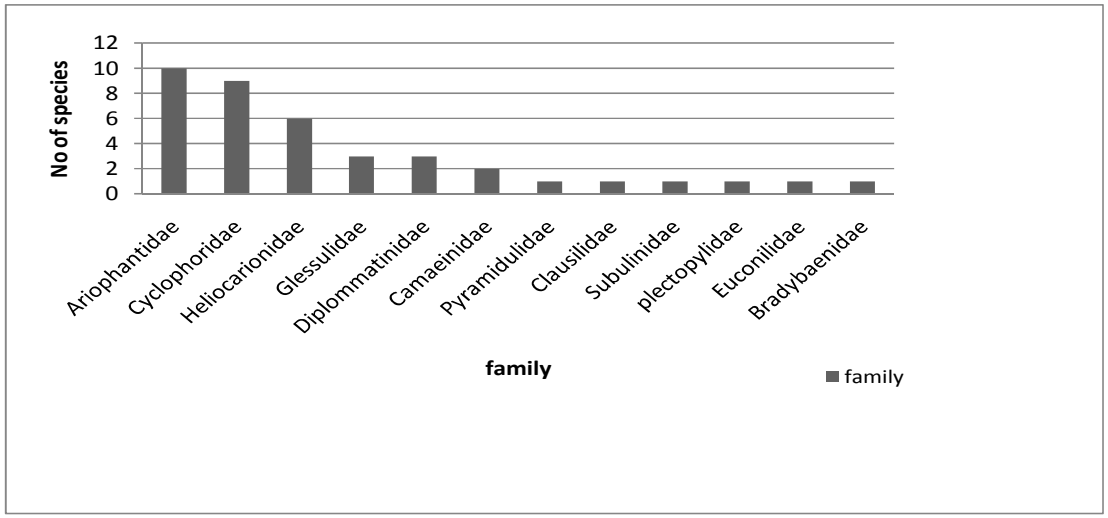

Figure 2. Diversity of land snails in Nagarjun Forest

Table 7: Species diversity of land snails in Nagarjun Forest

Species	pi=ni/N	Shannon Index H= -∑(ni/N) log (ni/N)	evenness index (e=H̄/logS)	Mean density		F	R.F	X^2	**r**
				Upper limit	Lower limit				
Theobaldius phenotopicus	0.00531	1.08775	0.678974	1.06	-0.39	23.81	2.66	32.00	-0.10 and 0.33
Alyceus bruti	0.14719			28.03	-9.55	76.19	8.51	332.3	
Alyceus plectochilus	0.06829			13.51	-4.94	52.38	5.85	368.73	

Alyceu Alycaeus cf bruti	0.01062			2.38	-0.86	19.05	2.13	57.50	
Alycaeus cf bicrenatus	0.00152			0.36	-0.17	4.76	0.53	40.00	
Chamalycaeus (Dicharax) sp.1	0.10243			19.70	-6.84	47.62	5.32	310.98	
Chamalycaeus digitatus	0.00303			0.63	-0.24	4.76	0.53	27.50	
Alycaeus cf inflatus	0.00076			0.18	-0.09	14.29	1.60	20.00	
Cyclophorus sp.	0.00076			0.18	-0.09	4.76	0.53	20.00	
Diplommatina sp.1	0.01366			2.73	-1.02	4.76	0.53	87.00	
Diplommatina sp.2	0.01138			2.48	-1.05	19.05	2.13	165.60	
Diplommatina folliculus	0.00228			0.49	-0.21	14.29	1.60	32.00	
Pyramidula humilis	0.00076			0.18	-0.09	9.52	1.06	20.00	
Hemiphaedusa sp.	0.00379			0.91	-0.43	4.76	0.53	100.00	
Allopeas sp.	0.03566			6.79	-2.31	4.76	0.53	79.45	
Plectopylis minor	0.10319			23.45	-10.50	42.86	4.79	2017.74	
Kaliella barakporensis	0.00607			1.22	-0.45	23.81	2.66	39.25	
Kaliella nana	0.00379			0.81	-0.34	19.05	2.13	49.60	
Kaliella dickrangensis	0.00228			0.49	-0.21	9.52	1.06	32.00	
Kaliella fastigiata	0.00303			0.65	-0.27	9.52	1.06	38.00	

Sitala sp.	0.00076			0.18	-0.09	9.52	1.06	20.00	
Cryptaustenia ovata	0.05159			9.73	-3.25	4.76	0.53	77.76	
Macrochlamys subjecta	0.00607			1.18	-0.42	66.67	7.45	23.50	
Macrochlamys perpaula	0.04249			8.22	-2.62	28.57	3.19	48.57	
Macrochlamys sp.A	0.00759			1.46	-0.51	66.67	7.45	23.60	
Macrochlamys sp.B	0.00303			0.65	-0.27	33.33	3.72	38.00	
Macrochlamys sp.C	0.00076			0.18	-0.09	9.52	1.06	20.00	
Macrochlamys longicauda	0.00379			0.74	-0.26	4.76	0.53	16.00	
Bensonies sp.1	0.11836			22.86	-8.00	23.81	2.66	398.62	
Khasiella sp.	0.01062			2.17	-0.84	57.14	6.38	88.00	
Bensonies nepalensis	0.00303			0.73	-0.35	14.29	1.60	80.00	
Syama prona	0.00379			0.80	-0.32	4.76	0.53	41.20	
Landouria savadiensis	0.02352			4.68	-1.73	14.29	1.60	137.68	
Ganessela sp.	0.00835			1.70	-0.65	19.05	2.13	67.27	
Euconulus sp.	0.00986			2.17	-0.93	14.29	1.60	156.62	
Bradybaena radicicola	0.00076			0.18	-0.09	14.29	1.60	20.00	
Rishetia sp.A	0.02200			4.52	-1.76	4.76	0.53	194.76	
Rishetia sp.B	0.00152			0.32	-0.13	14.29	1.60	19.00	

Rishetia longispira	0.01973			3.82	-1.34	9.52	1.06	70.92	

Shannon Index of species diversity (H=1.087) was obtained in Nagarjun forest.The species diversity is high where various factor interact with each other and among the individual.higher evenness index,e=0.67 indicates the more stable communities. Among the collected species *Alycaeus burti* is highly diversified with proportional abundance, Pi=0.147 and weakly diversified species like *Alycaeus cf inflatus, Cyclophorus* sp., *Pyramidula humilis., sitala* sp, *Macrochlamys* spC, *Bradybaena radicicola* with proportional abundance, pi=0.00076.

Among the reported species *Alycaeus burti* shows highest mean density with 28.03 and lowest mean density ranges 0.18 shown by many species like *A.*cf *inflatus, Cyclophorus* sp., *Pyramidula humilis, Sitala* sp., *Kaliella nana, Macrochlamys* sp.C, *Bradybaena* sp. respectively.

Frequency of each species was done by using above-mentioned formula. *Alycaeus burti* shows high relative frequency with 8.51 and many species like *Alycaeus* cf *bicrenatus, Cyclophorus* sp., *Chamalycaeus digitatus, Cyclophorus* sp., *Hemiphedusa* sp., *Allopeas* sp, *Cryptaustenia ovate, Macrochlamys longicauda, Syama prona,* shows lowest relative frequency (0.53.)

5.4. Sampling plots and species distribution pattern

Number of species ranges from 3 to 15 species per 10 m x 10 m plot. Average number of species per plot was 8.57. Species distribution pattern within sampling plots is shown in (Figure 3)

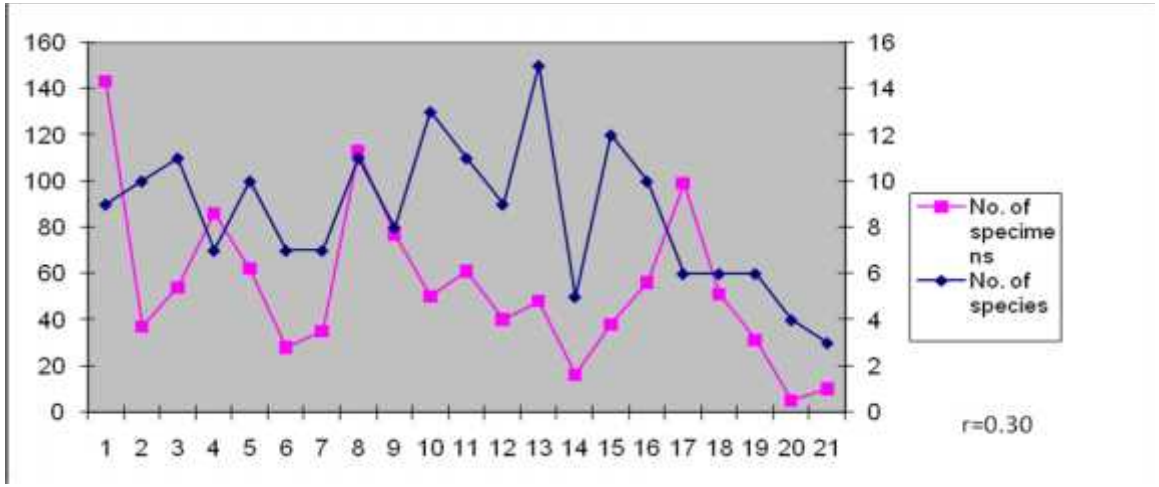

Figure 3: Species diversity of land snails in the 21 sampling plots

The above figure(3) clearly indicate that number of species is significantly correlated with the number of sampling plots (r = 0.30, p= 0.05). On the basis of species collected from 21 sampling plots, species accumulation curve was prepared (Figure 4). The curve shows that the current sample size is needed to increase to investigate terrestrial mollusc diversity in the study area.

Figure 4. Species accumulation curve of land snails in Nagarjun forest

5.5. Altitudinal distribution of land snails in Nagarjun Forest

Land snails collected within an elevational gradient of 1300 m - 1960 m above sea level. Correlation between elevation and land snail species was weakly negatively correlated (r = - 0.10). Land snail species were found patchily distributed within an elevational gradients. *Bensonies* sp., *Alycaeus* sp., *Cryptaustenia ovata, Macrochlamys, Chamalycaeus* sp. were distributed throughout sampling range from 1300-1960 m asl. But *Sitala*, *Pyramidula humilis* were only reported at elevation range of 1500m and *Cyclophorus* sp. was reported at elevation 1700 m only.

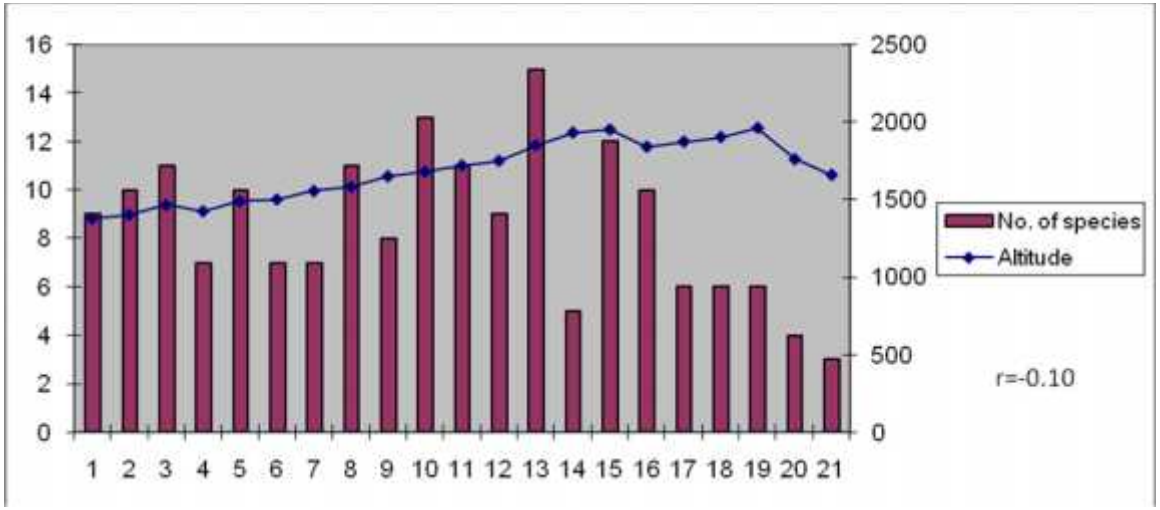

Figure 5. Altitudinal distribution of land snails in Nagarjun Forest

Diplommatina spp. were reported only at an elevation range of 1600m - 1800m. Many species *Kaliella* were reported at 1300 to 1800m. *Landouria savadiensis* and *Ganessella* sp. were found in the sampling plots rages from 1600-1800 m. *Chamalycaeus digitatus* and *Syama prona* were reported only at 1700-1800m. *Allopeas* sp. was reported at from 1300 to 1600m but not found above that altitude. *Plectopylis minor*, *Rishetia* sp. and *Glessula* sp. were reported up to 1700m. Distribution pattern of land snails in Nagarjun Forest shown that *Theobaldius* sp., *Alycaeus burti*, *Cyclophorus* sp., *Diplommatina* sp., *Hemiphedusa* sp., *Plectopylis* sp., *Cryptaustenia* sp., *Bensonies* sp., *Syama* sp., *Landouria* sp., *Ganessela* sp., *Euconulus* sp., *Bradybaena* sp. showed clumped distribution as($cal\chi^2 > tab\chi^2$, P=0.05, df=20) whereas *Rishetia* sp., *Sitala*, *Chamalycaeus*, *Marochlamys subjecta* showed random distribution as ($cal\chi^2 < tab\chi^2$, P=0.05, df=20).

5.6 Land snails fauna in relation with soil pH

Sampling plots of pH value of each plot was measured in lab. Land snail species were calculated at different pH value. Land snail diversity was reported highest in neutral or alkaline soil. There is not considerable difference in snail's diversity within these pH ranges. 28 species was reported at pH 6.5 to 7, 35 species at pH 7 to7.5 and 28 species at pH 7.5 to 8.

A relationship between Species diversity and soil pH was established by calculating correlation coefficient between them. They showed weak positive correlation with pH 0.33 which indicates that no. of species does not strongly depend on the soil pH but it will affect to some extend in distribution of species .

6. DISCUSSION AND CONCLUSION

A total of 1140 specimens representing 2 order, 12 families, 20 genera and 39 species were reported from Nagarjun forest within altitudinal range 1300 to 1960 m above sea level. Among the reported species, family Ariophantidae was dominant group containing 10 species, followed by Cyclophoridae (9), Heliocarionidae (6), Glessulidae (3), Diplommatinidae (3) and Camaeinidae (2). Family Pyramidulidae, Clausiliidae, Subulinidae, Plectopylidae, Euconulidae and Bradybaenidae each was represented by a single species. Literature review reveals that Cyclophoridae of Prosobranchia and Ariophantidae of Pulmonata were dominant families. These two families include the highest species diversity throughout the Indian subcontinent (Ramakrishna et al. 2010). Although the reproductive anatomy is good solution for species level conformation, this study is based on shell characters only due insufficient collection of live specimens. The identification key for family and generic level was based on shell characters only.

Shannon index of species diversity (H= 1.087) indicate that the Nagarjun forest was calculated as high species diversity. Higher evenness index (e = 0.67) indicates more stable the communities. Among the collected species *Alycaeus burti* was the abundant species throughout the sampling plots (Pi= 0.147). The following species *Alycaeus* cf *inflatus*, *Cyclophorus* sp., *Pyramidula* sp., *Sitala* sp, *Macrochlamys* sp.C, *Bradybaena radicicola* were the least abundant (pi=0.00076) species.

Species abundance does not follow same pattern. The numbers of specimens were ranged from 5 to 143 in the sampling plots. Similarly, representation of species ranges from 3 to 15 per 100 m². This highest numbers of specimens were collected at the base of mountain, which was obvious due to flushing out specimens from upper parts of the hill to the lower ultimately accumulating high number of species. Tattersfield et al. (2006) reported 19-167 specimens per 400m² per plot in Tanzanian forest. In the present study species density ranges from 0.18 to 28.030 in 100m². This number was comparable from 1 to 29 in 25 m^2 (Aubry et al. 2005). The number of species was increases with increasing number of specimens. Schilthuizen et al. (2003) also reported the same results from the limestone at Danun and Tabin site in Borneo.

Species richness is important features of communities that vary along elevational gradient. Land snails collected from 1300-1960m with different elevation gradient. Correlation between elevation and land snail species was calculated which indicates weak negative correlation with altitudinal gradient (r =-0.10). It signifies that land snail species decreases with increasing elevation. Diversity and distribution pattern of land snails in Nagarjun Forest shown that *Theobaldius* sp., *Alycaeus burti, Cyclophorus* sp., *Diplommatina* sp., *Hemiphaedusa* sp., *Plectopylis* sp., *Cryptaustenia* sp., *Bensonies* sp., *Syama* sp., *Landouria* sp., *Ganessela* sp., *Euconulus* sp., *Bradybaena* sp. showed clumped distribution whereas *Rishetia* sp., *Sitala, Chamalycaeus, Marochlamys subjecta* showed random distribution. Similarly, among the collected specimens *Bensonies* sp., *Alycaeus* sp., *Cryptaustenia ovata, Macrochlamys, Chamalycaeus* sp. were distributed throughout the altitudinal range from 1300-1960m. Many species were reported to be restricted in certain elevation only. Likewise, single species of *Sitala* sp. and *Pyramidula humilis* were collected from only at elevation of 1500 m and *Cyclophorus* sp. was reported at elevation of 1700 m only. Another single species of *Bradybaena* sp. and *Hemiphedusa* sp. were reported at elevation 1800m only. *Diplommatina* spp. *Landouria savadiensis* and *Ganessella* sp. were reported from 1600-1800 m. *Kaliella* sp. was reported at 1300 to 1800m. *Chamalycaeus digitatus* and *Syama* sp were reported only at 1700-1800m. Tattersfield (2001) demonstrated that mollusk fauna change gradually over the range 1782-2851 m and the faunal variation was more strongly related to rainfall than elevation and mollusk diversity declined with elevation over this range. Wronski (2008) reported relative species richness increases with increase in altitude up to 2000 m and with rainfall in Ugandan rainforest but decrease at higher altitude. Similarly, increase in altitude general result reduced species richness in both plant and animal (Macarthur, 1972 and Mccoy, 1990 cited in Aubry et al. 2005) in southeast France at elevation ranges 100 to 3100 m. Emberton et al. (1997) reported the highest mollusk richness at highest and lowest sites, although the pattern was probably strongly influenced by local factors, especially presence of lime stone at lowest elevation.

Land snails species were calculated against the different pH values and was positively correlated (r = 0.33), which indicates that number of species did not completely depend on the soil pH. Tattersfield et al. (2001) reported that correlation between soil pH and species richness was also negative in Mount Kenyan forests. But Raheem et al. (2008) showed weak positive correlation between soil pH and species composition. In

contrast, Schilthuizen et al. (2003) snail abundance was positively correlated with pH on limestone hill in Borneo with PH range 4 to 9. In limestome, containing high calcium carbonate contents act as buffer against acidity that is accompanied with high pH.

The species accumulation curve was plotted which indicated that the present number of species diversity showed the increasing trends. It means the present sampling plots were insufficient to represent the total species diversity in the area. Raheem et al. (2008) demonstrate that species accumulation curve for low land rain forest was high in comparison to garden in Sri Lanka. That curve indicated that greater land snail species richness in low land. Unlike that, Aubry et al. (2005) demonstrated that species accumulation curve showing the pattern of high species richness in plateau at altitude below 1000 m in south east France.

RECOMMENDATIONS

This is the first initiation in Nagarjun forest. The sampling plots shown by this study represented the insufficient sampling units which need to be increased by many folds to cover total species diversity in the forest.

Land snails are very slow moving animals and have been distributed in a limited area. Most of the species are range restricted. Hence they are very important indicators for the climate change. Further investigations regarding to their distribution range in relation with high degree of elevational differences can yield some results with changing climatic factors.

Appendix 1. Landsnails sampled in 10x10m plots in Nagarjun Forest

No. of plots	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**Total**
Altitude	1378	1403	1466	1426	1490	1502	1556	1582	1650	1680	1720	1750	1850	1930	1950	1840	1873	1902	1960	1760	1660	
Theobaldius phenotopicus	0	0	0	0	0	0	0	0	1	3	0	1	1	0	1	0	0	0	0	0	0	**7**

Alycaeus bruti	5	2	9	50	25	0	0	29	4	6	10	8	0	0	4	10	6	20	3	0	3	**194**
Alycaeus plectochilus	0	1	0	0	5	0	3	3	0	4	7	0	0	0	0	12	40	10	0	2	3	**90**
Alycaeus cf bruti	0	2	0	3	3	0	3	5	0	0	0	0	0	0	0	0	0	0	0	0	0	**16**
Alycaeus cf bicrenatus	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	**2**
Chamalycaeus dicharax sp1	0	3	14	20	12	0	0	15	0	0	5	0	6	6	0	0	40	14	0	0	0	**135**
Chamalycaeus digitatus	0	0	0	0	0	0	0	0	0	0	1	0	1	2	0	0	0	0	0	0	0	**4**
Alycaeus cf inflatus	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**
Cyclophorus sp	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	**1**
Diplommatina sp1	0	0	0	0	0	0	0	0	0	0	0	0	3	0	4	7	0	0	4	0	0	**18**
Diplommatina sp2	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	11	0	0	0	0	0	**15**
Diplommatina folliculus	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	**3**

Pyramidula humilis	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**
Hemiphedusa sp	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	**5**
Paropeas achatinaceus	0	2	2	6	7	5	0	7	4	8	6	0	0	0	0	0	0	0	0	0	0	**47**
Plectopylis minor	117	16	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	**136**
Kaliella barakporensis	2	0	2	0	0	3	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	**8**
Kaliella nana	0	0	0	0	0	3	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	**5**
Kaliella dickangensis	0	0	0	0	0	0	0	0	0	2	0	0	1	0	0	0	0	0	0	0	0	**3**
Kaliella fastigiata	2	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**4**
Sitala sp	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**
Cryptaustenia ovata	1	4	8	2	3	12	5	2	6	9	8	2	0	0	0	4	0	0	2	0	0	**68**
Macrochlamys subjecta	1	2	0	0	0	0	0	0	0	1	0	2	1	0	0	0	1	0	0	0	0	**8**
Macrochlamys perpaula	0	0	5	0	0	2	4	3	7	5	5	1	0	0		3	9	3	4	1	4	**56**

Macrochlamys spA	0	0	0	0	1	0	0	0	0	0	1	0	2	2	0	2	0	1	0	1	0	**10**
M.spB	0	0	0	0	2	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	**4**
Macrochlamys spC	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	**1**
Macrochlamys longicauda	0	0	1	0	0	0	1	1	0	1	0	1	0	0	0	0	0	0	0	0	0	**5**
Bensonies sp1	4	0	10	0	0	0	0	37	45	0	10	17	9	0	7	3	3	3	8	0	0	**156**
Khasiella sp	0	0	0	0	0	0	0	0	4	4	0	0	0	0	6	0	0	0	0	0	0	**14**
Bensonies nepalensis	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**4**
Syama prona	0	0	0	0	0	0	0	0	0	0	0	1	3	0	0	1	0	0	0	0	0	**5**
Landouria savadiensis	0	0	0	0	0	0	0	0	0	0	6	0	8	0	7	0	0	0	10	0	0	**31**
Ganessela sp	0	0	0	0	0	0	0	0	4	4	0	0	0	0	0	3	0	0	0	0	0	**11**
Euconulus sp	0	0	0	0	0	0	0	10	0	0	0	0	0	0	2	0	0	0	0	1	0	**13**

Bradybaena radicicola	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	**1**
Rishetia sp A	0	0	0	0	0	0	14	0	0	0	0	7	8	0	0	0	0	0	0	0	0	**29**
Rishetia sp B	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	**2**
Rishetia longispira	7	4	2	4	3	1	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**26**
Total	**143**	**37**	**54**	**86**	**62**	**28**	**35**	**113**	**77**	**50**	**61**	**40**	**48**	**16**	**38**	**56**	**99**	**51**	**31**	**5**	**10**	**1140**
No_indiv	143	37	54	86	62	28	35	113	77	50	61	40	48	16	38	56	99	51	31	5	10	
No_sps	9	11	10	12	10	4	7	12	10	13	8	6	13	6	14	10	7	5	7	5	4	
No_gen	10	8	10	9	5	6	7	8	10	8	6	8	9	4	6	7	5	4	3	4	6	
No_fam	6	5	6	7	5	4	4	6	5	5	5	4	6	3	6	5	3	2	2	3	5	
pH	7.9	7.7	7.2	7.9	7.3	6.8	7.9	7.3	7.7	7.6	6.8	7.9	7.4	7.8	8.2	6.8	7.7	7	7.2	7	7.5	

Appendix 2. Checklist of terrestrial snails of Nepal

Class: **GASTROPODA**

Subclass: Prosobranchia

Order: Caenogastropoda Cox, 1960

Family: Cyclophoridae Gray, 1847

Genus *Cyclophorus* Montfort, 1810

1. *Cyclophorus (Glossostylus) fulguratus* (Pfeiffer, 1852)
2. *Cyclophorus (Litostylus) pyrotrema* Benson, 1854
3. *Cyclophorus (Salpingophorus) aurantiacus* (Schumacher, 1817)

Genus *Theobaldius* Nevill, 1878

4. *Theobaldius phaenotopicus* (Benson, 1851)

Genus *Alycaeus* Gray, 1850

5. *Alycaeus (Alycaeus) burti* Godwin-Austen, 1874
6. *Alycaeus (Alycaeus) lohitensis* Godwin-Austen, 1914
7. *Alycaeus plectochilus* Benson,1859
8. *Alycaeus inflatus* Godwin-Austen, 1874
9. *Chamalycaeus (Dicharax) bicrenatus* (Godwin-Austen, 1871)
10. *Chamalycaeus (Dicharax) digitatus* (Blanford, 1871*).*
11. *Chamalycaeus (Dicharax) notaus* (Godwin-Austen, 1876)
12. *Chamalycaeus (Cycloryx) otiphorus* (Benson, 1858)
13. *Chamalycaeus (Cycloryx) summus* (Godwin-Austen, 1871)
14. *Diplommatina (sinica)canarica* Bedome,1875
15. *Diplommatina oviformis* Fulton, 1901

16. Diplommatina pachychilus Benson, 1857

17. Diplommatina sperata W. Blanford, 1862

18. Diplommatina folliculus (Pfeiffer, 1846)

Subclass: Pulmonata

Order: Basommatophora Keferstein, 1865

Family: Ellobidae L. Pfeiffer, 1854

19. Carychium minusculum Gredler, 1887

Order: Systellommatophora

Family: Pyramidulidae Kennard & Woodward, 1914

Genus *Pyramidula* Fitzinger, 1833

20. Pyramidula humilis (Benson, 1838)

Family: Clausiliidae J.E.Gray, 1855

Genus *Hemiphaedusa* O. Boettger, 1877

21. Hemiphaedusa ioes jiriensis (Nordsieck 1973)

22. Hemiphaedusa kathmandica (Nordsieck 1973)

23. Hemiphaedusa martensiana (Nordsieck 1973)

Family: Subulinidae P. Fischer & Crosse, 1877

Genus *Allopeas* H. B. Baker, 1935

24. Allopeas mauritianus prestoni (Sykes, 1898)

Genus *Bacillum* Theobald,1870

Family: Plectopylidae Möllendorff, 1898

Genus *Plectopylis* Benson, 1860

25. Plectopylis (Endothyrella) affinis Gude, 1897

*26. Plectopylis (Endothyrella) minor (*Godwin-Austen, 1879)

Family: Helicarionidae Bourguignat, 1877

Genus *Kaliella* Blanford, 1863

27. Kaliella barrakporensis (L.Pfeiffer, 1852)

28. Kaliella nana (Hutton, 1838)

29. Kaliella fastigiata (Hutton,1838)

30. Kaliella nana (Hutton,1850)

31. Kaliella dickrangensis Godwi-Austen,1883

Genus *Sitala* H. Adams, 1 865

32. Sitala rimicola (Benson, 1859)

Genus *Cryptausatenia* Cockerell, 1891

33. Cryptaustenia cf. *globosa* (Godwin-Austen, 1876)

34. Cryptaustenia ovata (H. Blanford, 1871)

Family: Glessulidae Godwin-Austen, 1920

Genus *Glessula* von Martens, 1860

35. Glessula subjerdoni Beddome, 1906

Genus *Rishetia* Godwin-Austen, 1920.

36. Rishetia tenuispira (Benson, 1836)

37. Rishetia longispira (Godwin-Austen, 1920)

Family: Ariophantidae Godwin-Austen, 1888

Genus *Macrochlamys* Gray, 1847

38. Macrochlamys indica Godwin-Austen, 1883

39. Macrochlamys lata (?) Godwin-Austen, 1888

40. Macrochlamy longicauda Godwin-Austen, 1883

41. Macrochlamys lubrica (Benson, 1852)

42. Macrochlamys patane (Benson, 1859)

43. Macrochlamys nuda (L. Pfeiffer, 1852)

44. Macrochlamys sathilaensis Godwin-Austen, 1883

45. Macrochlamys sequax (Benson, 1859)

46. Macrochlamys sequius (Godwin-Austen, 1907)

47. Macrochlamys subjecta (Benson, 1852)

48. Macrochlamys tugurium(Benson,1852)

49. Macrochlamys perpaula (Benson,1859)

Genus *Euaustenia* Cockerell, 1891

50. Euaustenia monticola (L. Pfeiffer, 1848)

Genus *Bensonies* H.B. Baker, 1938

51. Bensonies nepalensis (Blanford, 1878)

52. Bensonies convexa (Reeve, 1852)

Genus *Himalodiscus* Kuznetsov, 1996

53. Himalodiscus aculeatus Kuznetsov, 1996

54. Himalodiscus echinatus Schileyko and Kuznetsov, 1998

Genus *Khasiella* Godwin-Austen, 1899

55. Khasiella ornatissima (Benson, 1859)

56. Khasiella pansa (Benson, 1856)

Genus *Oxytesta* Zilch, 1956

57. Oxytesta blanfordi (Thoebald, 1859)

58. Oxytesta orobia (Benson, 1848)

59. Oxytesta sylvicola (Blanford,1880)

Genus *Syama* Godwin-Austen,1908

60. Syama prona (Nevill, 1878)

Genus *Taphrospira* Blanford, 1905

61. Taphrospira convallata (Benson, 1856)

62. Taphrospira compluvialis (Blanford, 1865)

Genus *Rotungia* Godwin-Austen, 1918

63. Rotungia williamsoni Godwin-Austen,1918

Family: Camaenidae Pilsbry, 1895

Genus *Landouria* Godwin-Austen, 1918

64. Landouria aborensis Godwin-Austen, 1918

65. Landouria coeni (Preston, 1914)

66. Landouria dhaulagirica Kuznetsov and Schileyko, 1997

67. Landouria huttoni (L. Pfeiffer, 1842)

68. Landouria rhododendronis Kuznetsov and Schileyko, 1997

69. 59 Landouria savadiensis (Nevill, 1877

Family: Bradybaenidae Pilsbry, 1934

Genus: *Bradybaena* Beck, 1837

70. Bradybaena radicicola (Benson, 1848)

71. Bradybaena ? thakkholensis Schileyko and Kuznetsov, 1998

Family: Euconulidae Baker, 1928

Genus *Euconulus* Reinhardt, 1883

72. Euconulus fulvus (O.F. Muller, 1774).

Family: Veronicellidae Gray, 1840

Genus *Laevicaulis* Simroth, 1913

73. Laevicaulis alte (A. Férrusac, 1821)

Order: Stylommatophora

Family: Pupillidae Turton, 1831

Genus *Pupilla* L.fleming, 1828

74. Pupilla eurina (Benson, 1864)

75. Pupilla triplicata (Studer, 1820)

Family: Valloniidae Morse, 1864

Genus *Vallonia* Risso, 1826

76. Vallonia ladacensis (Nevill, 1878)

77. Vallonia tenuilabris (A. Braun, 1843)

78. Vallonia costohimalya Gerber and Bössneck , 2009

79. Vallonia himalaevi Gerber and Bössneck , 2009

80. Vallonia kathrinae Gerber and Bössneck , 2009

Family: Vertiginidae Fitzinger, 1833

Genus *Truncatellina* Lowe, 1852

81. Truncatellina sp

Genus *Gastrocopta* Wollaston, 1878

82. Gastrocopta huttoniana (Benson, 1949)

Family: Enidae Woodward, 1903

Genus *Pupinidius* Moellendorff, 1901

83. Pupinidius himalayanus Kuznetsov and Schileyko, 1999

84. Pupinidius siniayevi Kuznetsov and Schileyko, 1999

85. Pupinidius tukuchensis Kuznetsov and Schileyko, 1997

Genus *Laevozebrinus* Lindholm, 1925

86. Laevozebrinus nepalensis Schileyko and Frank,1994

87. Laevozebrinus nepalensis myagdiensis Schileyko and Frank,1997

88. 76. Laevozebrinus mustangensis Kuznetsov and Schileyko, 1997

Genus *Mirus* Albers, 1850

89. Mirus (?) *nilagiricus* (L. Pfeiffer, 1846)

Genus *Nepaliena* Schileyko and Frank, 1994

90. 78. Nepaliena ceratina (Benson, 1849)

Family: Achatinidae Swainson, 1840

Genus *Lissachatina* Bequaert, 1951

91. Lissachatina fulica (Bowdich, 1822)

Family: Streptaxidae Gray, 1860

Genus *Sinoennea* Kobelt, 1904

92. Sinoennea stenopylis (Benson, 1860)

Family: Limacidae Lamarck, 1801

Genus *Limax* Linnaeus, 1758

93. Limax seticus Wiktor and Bössneck, 2004

Genus *Turcomilax*

94. Turcomilax (Taumilax) oli Wiktor, Naggs and Kumar, 1999

Family: Agriolimacidae Wagner, 1935

Genus *Deroceras* Rafinesque, 1820

95. Dearoceras laeve (Müller, 1774)

Family: Vitrinidae Fitzinger, 1833

Genus *Hawaiia* Gude, 1911

96. Hawaiia sp.

Family: Anadenidae Pilsbry, 1948

Genus *Anadenus* Heynemann, 1862

97. Anadenus altivagus (Theobald, 1862)

98. Anadenus nepalensis Wiktor, 2001

99. Anadenus (Sagarmathia) kuznetsovi Kuzminykh and Schileyko, 2005

Family: Philomycidae Gray, 1847

Genus *Meghimatium* van Hasselt, 1823

100.Meghimatium cf *pictum* (Stoliczka, 1873)

Note: This checklist is prepared by using the best available literatures Nordsieck 1973, Schileyko and Frank 1994, Kuznetsov and Schileyko 1997, 1999, Schileyko and Kuznetsov 1996, 1998a, 1998b,Kuzminykh and Schileyko 2005, Wiktor 2001, Bössneck 2006, Gerber and Bössneck 2009, Subba and Ghosh 2000, 2001, 2008, Subba 2003, Thapa 2003, Budha 2005, 2007, Budha and Naggs 2008, Ramakrishna et al 2010, Raheem et al 2010, Blanford and Godwin-Austen 1908, Gude 1914, 1921)

REFERENCE

Abury, S., Magnin, F. Bonnet V., and Preece, R.C. 2005. Multiscale altitudinal pattern in species richness in land snail communities in south-eastern France. Journal of Biogeography 32:985-998.

Benson, W.H. 1857. Characteristic of *Streptatulus* a new genus and several species of Cyclostomacea from Sikkim, Kashi Hills Ava and Pegu. Ann. Mag. Nat.Hist. (2)14:411-418.

Blanford, W.T.1865. Notes on the variation of some Indian and Burmese Helicidae with an attempt at rearrangement together with description of new Burmese Gastropoda. J.Asiat.Soc.Beng., 38:230-250.

Blanford, W.T., and Godwin-Austen, H.H. 1908. The Fauna of British India, including Ceylon and Burma, Mollusca. Vol. I (Testacellidae and Zonitidae). Today and Tomorrow's Printers and Publishers, New Delhi.

Bössneck, U. 2006. Ökologie und verbreitrung der Nacketschenecken im Nepal Himalaya (Molluca: Gastropoda: Pulmonata. In Hertmann, M. & J. Weipert

(eds). Biodiversitat and Naturausstattung im Nepal Himalaya Biodiversity 2: 39-48.

Budha, P.B. 2005. Nepalese Malacology trails behind 'Catch Up'. Himalayan Journal of Sciences. 3(5): 9-10.

Budha, P.B. 2007. Nepal Ka Shankhekira Ko Chinari. A newsletter of Center for Biological Conservation Nepal (in Nepali).

Budha, P.B., Backeljau, T., and Naggs, F. 2007. The distribution of terrestrial land snails in Nepal. A Poster Presented at the World Congress of Malacology, Belgium, July 15-20, 2007.

Budha, P.B., Aravind, N.A. and Daniel, B.A.2010. The Status and distribution of freshwater mollusks of Eastern Himalaya.In: Allen, D.J. Muller, S. and Daniel, B.A. (Compiler). Cambridge, UK and Gland Switzerland: IUCN and Coimbatore, India Zoo outreach organization.

Budha, P.B., Naggs, F. 2005. The Giant African Land Snail *Lissachatina fulica* (Bowdich) in Nepal. The Malacologia, 50:19-21.

Chaudhary,R.P. 1998. Biodiversity in Nepal-Status and Conservation. Tecpress Books, Bangkok, Thailand.

DNPWC, 2009. Shivapuri Nagarjun National Park. Brochure. Babarmahal, Kathmandu, Nepal

Dey, A., Barua, S. and Mitra, S.C.1985. Mollusca of Proposed Namdapha Biosphere Reserve, Rec. Zool. Surv.India, 82 (1-4):263-174.

Dey, A., and Mitra, S.C. 2000. Mollusks of the Himalaya. Rec. Zool. Survey. India **98**(2):5-50.

Dey, A., Barua, A., and Mitra, S.C. 2003. Mollusca-In: Fauna of Sikkim, Parts 5-Zoological Survey of India (Kolkata) State Fauna Series 9:129-144.

Emberton, K.C. 1997. Diversities and distributions of 80 landsnail species in southeastern-most Madagascan rainforests, with a report that lowlands are richer than highlands in endemic and rare species. Biodiv. Conserv. 6:1137-1154.

Gerber, J. and Bössneck, U. 2009. The genus *Vallonia* in Nepal (Gastropoda: Pulmonata: Valloniidae).Arch. Molluskenkunde 138(1):43-52.

Godwin-Austen, H.H. 1916. Zoological Results of the Abor Expedition Mollusca 6. Records of Indian Museum. 547-559.

Godwin-Austen H.H.1918. Zoologocal results of Abor Expedition, 1911-12.XLIX. Mollusca, IX. Records of Indian Museum, 8(12): 601-612.

Gordan, D.1983. Pest slug and snails. Springer-Verlag, Berlin Heidelberg, New York.

Gude, G.K. 1921. The Fauna of British India, including Ceylon and Burma; Mollusca, Volume III: Land Operculates (Cyclophoridae, Truncatellidae, Assimineidae, Helicinidae). Today and Tomorrow's Printers and Publishers, New Delhi.

Gude, G.K., 1914. The Fauna of British India, including Ceylon and Burma, Mollusca, Vol II (Trochomorphidae-Janellidae). Today and Tomorrow's Printers and Publishers, New Delhi.

Hutton, T. 1834. On The Land shells of India. J.Asiat.Soc.Beng.,3:81-93.

Khanal, B. and Smith, C. 1996. Butterflies of Kathmandu Valley, Nepal (Field guide, including all known records to date) Know Nepal series No. 13. Tecpress Books, Bangkok, Thailand. p.112.

Kanai, H., and Shakya, P.R.1970. Vegetation survey of Nagarjun forest. In: DMP (1973), Bulletin of Department of Medicinal Plants no.4-Flora of Nagarjun. Published by His Majesty’s Government of Nepal, Ministry of Forest, Department of Medicinal Plants, Thapathali, Kathmandu, Nepal. pp:iii-vi,1-93 and I-XIX.

Kuznetsov, A.G., and Schileyko, A.A. 1997. New Data on Enidae (Gastropoda, Pulmonata) of Nepal. Ruthenica **7** (2): 133-140.

Kuznetsov, A.G., and Schileyko, A.A. 1999. Two new species of the genus *Pupinidius*, Moellendorff, 1901 (Enidae, Pulmonata) and the distribution of the genus in Nepal, Ruthenica **9**(2): 117-121.

Kuzminykh, A.A., and Schileyko, A.A. 2005. Slugs of Anadenidae Pilsbry,1948 (Gastropoda,Pulmonata) with description of two new subgenera and three new sp.Ruthenica 15(2):109-118.

Malla, R. 2000. Diet analysis of *Hipposiderous armiger* and *Rhinolophus pursillus* (Microchiroptera) of Nagarjun cave. M.sc. thesis submitted to Central Department of zoology. T.U, Kirtipur, KTM.

Lydeard, C., Cowie, R.H., Ponder, W.F., Bogan, A.E., Bouchet, P., Clark, S.A., Cummings, K.S., Forest, T.J., Gargoming, O., Herbert, G.D., Hersbles, R., Pervez., K.E., Roth, B., Seddon, M., Strong, E.E., and Thompson. F.G. 2004. The global decline of non Marine Mollusks. Bioscience **54**(4): 321-330.

Mookherjee, H.P., Thakur, D.K., Mitra, S.C., and Barua, S., 2000. Mollusca: Fauna of Tripura. Rec. Zool. Surv. India, State fauna Series, 7(4):323-355.

Mitra, S.C., and Dey, A. 1990. Land Mollusc of Teirei River Valley Project, Darlak (Mizoram: India). Rec. Zool. Surv. India, 86:47-67.

Mitra, S.C., and Dey, A. 1992. Land and Freshwater mollusks (Part1). Fauna of West Bengal. Part 9: 1-51. State Fauna Series : Pub: Zoological Survey of India,Kolkata.

Mitra, S.C. Dey. A. and Ramakrishna, 2005. Pictorial handbook, Indian Land Snails, Zoological Survey of India, Kolkota.

Naggs, F. 1997. William Benson and the early study of Land Snails in British India and Ceylon. Achieves of Natural History 24(1): 37-38.

Nesemann, H., Sharma, S., Sharma, G., Khanal, S.N., Pradhan, B., Shah, D.N., Tamacho, R.D., 2007. Aquatic Invertebrates of the Ganga River System . Mollusca,Annelida,Crustacea (Part 1). H. Nesemann. Vol.1, 242 pp.

Nevill, G. 1878. Mollusca from Kashmir and neighbourhood of Mari (Murree) in Panjab. In: Scientific Results of Second Yarkand Misson, Mollusca. London: 4-21.

Nordsieck, H. 1973. Zur Anatomie und systematic der Clausilien XII. Phaedusinae, I:Phaedusen aus Nepal und ihre systematische stellung innerhalb der Unterfamilie Arch. Moll. **103**(1-3):63-85.

Ranabhatt, BS.1978. Vegetational analysis of the Balaju adjoining hills in Nagarjun Royal Forest area. Central Department of Botany, Tribhuvan University, Kathmandu.

Ramakrishna., Mitra. S.C., Dey. A. 2010. Annotated Checklist of Indian Land Molluscs. Zoological Survey of India, Kolkata.

Reheem, D.C., Budha. P.B., Naggs, F. and Preece, R. 2010. An illustrated Guide to the land snails of Nepal. The Natural History Museum, London.

Raheem, D. C., F. Naggs, R. C. Preece, Y. Mapatuna, L. Kariyawasam, and Eggleton, P. 2008. Structure and conservation of Sri Lankan land-snail assemblages in fragmented lowland rainforest and village home gardens. J. Appl. Ecol. 45(4):1019-1028.

Schileyko A.A. Frank, C.1994. Some Terrestrial Mollusca of the Nepalesian Fauna. Arch. Moll., **123** (1/6): 127-136

Schileyko, A.A. and Kuznetsov, A.G. 1996. A new genus of Subulinidae (Pulmonata) from Nepal. Ruthenica **5**(2): 158-160

Schileyko, A.A. and Kuznetsov, A.G. 1998a. Land Snails of the Genus *Landouria* Godwin- Austen 1918, and some other Bradybaenidae of Nepal (Gastropoda, Pulmonata). Ruthenica **8**(1): 43-54.

Schileyko, A.A., Kuznetsov, A.G. 1998b. On the taxonomic Position of the genus *Himalodiscus* Kuznetsov, 1996 with a description of a new species. Ruthenica **8**(1): 85-88.

Schilthuizen, M., Chai, H.N., Kimsin, T.E. 2003. Abundance and diversity of land-snails (Mollusca: Gastropoda) on limestone hills in Borneo. The Raffles Bulletin of zoology, 51(1):35-42.

Sharma, C.K.,1973. Geology of Nepal, Kathmandu.

Subba, B.R. 2003. Molluscan checklist of Ghodaghodi Tal area, Kailali district. Our Nature 1:1-2.

Subba, B.R., and Ghosh, T.K. 2000. Some Fresh water Mollusca from Eastern and Central Nepal. Journal of Bombay Nat. Hist. Soc. **97**(3): 452-455.

Subba, B.R. and Ghosh, T.K. 2001. Terrestrial Mollusks from Nepal. Journal of the Bombay Natural History Society. **98**(1): 58-61

Subba, B.R. and Ghosh, T.K. 2008. Report on some terrestrial molluscs from different region of Nepal. J. nat. Hist. Mus.23:72-81.

Subba Rao NV. 1989. Freshwater Mollusc of India. Zoological Survey of India, Kolkata.xxiii+289p

Surya Rao, N.V. and Mitra S.C.1995. Mollusca. In: Fauna of Western Himalaya, Part 1. Uttar Pradesh, Zoological Survey of India (Kolkata), Himalayan Ecosystem Series I: 11-15.

Tattersfield, P. 1996. Local Patterns of Land Snail diversity in a Kenya rain Forest. Malacologia 38(1-2): 161-180.

Tattersfield, P., Warui, C.M., Seddon, M.B. & Kiringe, J.W. 2001. Land-snail faunas of Afromontane forests of Mount Kenya, Kenya: ecology, diversity and distribution patterns. J. Biogeogr. 28:843–861.

Tattersfield, P. Seddon, M. B., Ngereza, C. and Rowson, B. 2006. Elevational variation in diversity and composition of land snail faunas in a Tanzanian forest. J. Afric. Ecol . 44: 47-60.

Thapa, D. 2003. Molluscan diversity of Koshi Tappu Wildlife reserve and its surrounding area. Our nature **1**:73-74.

Thapa, V.K.1997. An Inventory of Nepal's Insects. Vol 1 (Protura-Odonata). Biodiversity Publication Series 1. IUCN Nepal, Kathmandu. 98 pp.

Thapa, V.K.1998. An Inventory of Nepal's Insect. Vol 2.IUCN Nepal, KTM, xii+ 245 pp.

Thakur, D.K., Mitra, S.C, and Mitra, S.1992. Land and Freshwater Mollusc, Part ii-In: Fauna of West Bengal, Part 9. Zoological Survey of India (Kolkata) State Fauna Series 3:53-127.

Wiktor, A., 2001. A Review of Anadenidae (Gastropoda: Pulmonata) with a Description of a new species. Folia Malacologica 9(1): 3-26.

Wiktor, A. and Bössneck, U. 2004. *Limax (Limax) seticus* n. sp. from high mountains in Nepal (Gastropoda: Pulmonata: Limacidae). Folia Malacologcia 12(4):183-18

Wronski, T., Hausdrof, B. 2008. Distribution pattern of land snails in Ugandan rain forest support the existence of Pleistocene forest refugia. Journal of Biogeography.35:1759-1768.