Journal of the Andaman Science Association Vol. 25(1):1-8 (2020)
ISSN 0970-4183, Printed in India

Carbon Isotopes in Soil Organic Matter Dynamic Studies

Kiran Karthik Raj*, **A. Velmurugan., T. P. Swarnam, T. Subramani and Sirisha Adamala**
ICAR-Central Island Agricultural Research Institute, Port Blair - 744 105
Corresponding author, e-mail:kiran14iari@gmail.com

Abstract

Carbon exists in different isotopic forms *viz.* ^{12}C, ^{13}C and ^{14}C. The degree of carbon fractionation that takes place in a given sample can be estimated by measuring the ratio of amounts of ^{13}C and ^{12}C isotopes, and the ratio ($^{13}C/^{12}C$) is expressed as a relative value to the standard *viz.* Pee Dee Belemnite (PDB). ^{13}C is less preferred by soil microbes, as compared to ^{12}C, which results in ^{13}C discrimination in soil. Due to continuous release of more 'light CO_2 ($^{12}CO_2$)', the evolution of 'heavy CO_2 ($^{13}CO_2$)' is relatively abridged, resulting in selective enrichment of ^{13}C in the recalcitrant soil organic carbon (SOC) pools. Plants fabricate organic residues with different $^{13}C/^{12}C$ composition which could be attributed to their differential ability in utilizing C isotopes. During photosynthetic uptake of CO_2, C-3 plants discriminate ^{13}C to a higher extent than that of C-4 plants. Thus, relatively lower $\delta^{13}C$ values is reported in C-3 plants (-22 to -33‰) as compared to higher values in C-4 plants (-9 to -16‰). Reports from the long term fertilizer experiments revealed that $\delta^{13}C$ value correlated well with deep soil C sequestration. By using $\delta^{13}C$ value and using empirical equations, the proportion of SOC derived from new and old carbon stocks can be gauged through the mass balance of C isotopes.

Key words: ^{13}C, carbon dynamics, isotopes, soil organic matter

Introduction

Earth is a dynamic system, wherein carbon cycle, move and partition between different components *viz.* plants, soil, ocean, air and even rocks. Plants capture carbon dioxide (CO_2) from the atmosphere in presence of sunlight to make their own food and accumulate as plant biomass, which in turn became animal biomass through food chain system. After death, the plant and animal biomass get decomposed to form soil organic matter. Carbon is the chief constituents in biological compounds as well as a major component of many minerals such as limestone. Meanwhile a part of the carbon will be cycled back through respiration and methane emission. Carbon dioxide from the atmosphere dissolves into water bodies (ocean, lakes, ponds *etc.*). Thus, carbon will be cycled between biosphere, pedosphere, geosphere, hydrosphere, and atmosphere of the Earth. Soil organic carbon (SOC) in agro-ecosystems plays key role in soil fertility, nutrient cycling, sustainability of land through its effect on soil physical, chemical and biological properties (Kabiri et al., 2015; Tian et al., 2015). Soil organic matter (SOM) play vital role in improving the soil resilience and decreases soil erosion (Majumder *et al.,* 2008). Sustainability of land is harmfully affected by faulty management practises (Qin *et al.,* 2015). Soil organic carbon (SOC) contents are being constantly dwindling and SOC loss is amplified in degraded lands (Zuazo & Pleguezuelo, 2008).

Carbon exists in different isotopic forms *viz.* ^{12}C, ^{13}C and ^{14}C and can be used as tracer to profile various ecological functions and plant adaptations (Raj *et al.*, 2019; Raj *et al.*, 2020). Carbon-12 (^{12}C) and carbon-13 (^{13}C) are stable non radioactive isotopes, and carbon-14 (^{14}C; also known as radiocarbon) is an unstable radioactive isotope. It was reported that ratio of ^{14}C to ^{12}C is approximately 1.25 parts of ^{14}C to 10^{12} parts of ^{12}C (Tsipenyuk, 1997).

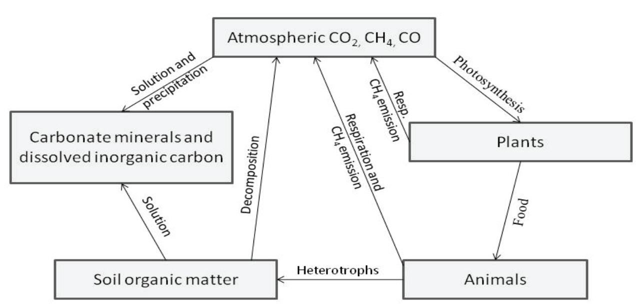


Fig. 1: Cycling of carbon between different components of the earth system

Determining the age of organic materials through radiocarbon dating

The method was developed by Willard Libby. The interaction of cosmic rays with atmospheric nitrogen results in the production of radiocarbon (^{14}C), which combines with oxygen to form radioactive carbon dioxide ($^{14}CO_2$). Plant incorporates it into the biomass through photosynthesis; animals acquire ^{14}C by consuming the plants. Once the plant or animal dies, uptake of carbon with the environment gets curtailed, and subsequently ^{14}C content begins to decline within the sample through radioactive decay. Assessing the amount of ^{14}C in a dead plant or animal sample provides information that can be used to determine the age of the sample. The older a sample, the lesser will be ^{14}C content in it. Since the half-life of ^{14}C is about 5,730 years, the oldest age that can be consistently measured by this process is about 50,000 years. Further, corrections should be made to account the proportion of ^{14}C fractionation in different types of organisms, and the reservoir effects through varying levels of ^{14}C within the biosphere.

^{13}C discrimination in soils

Carbon discrimination refers to selective accumulation of ^{13}C in SOC. Although ^{13}C discrimination in soils is well recognized, the connection of ^{13}C abundance is not established. Further, it remains ambiguous to clearly trace the effect of such carbon discrimination on the overall distribution of ^{13}C in SOC. ^{13}C was less preferred by soil microbes, as compared to ^{12}C, at early stages of residue decomposition, which would result in ^{13}C discrimination and preferential release of "light CO_2 ($^{12}CO_2$)" in gaseous form was reported (Flessa et al., 2000). Due to the continuous release of more light CO_2, "heavy CO_2 ($^{13}CO_2$)" evolution was relatively abridged. Thus, higher ^{13}C accumulation in soil was the result of discrimination in heavy CO_2 evolution (Dalal et al., 2013).

Carbon sequestration and ^{13}C natural abundance

Carbon sequestration refers to capturing and storing C in long lived pools and it is considered as an effective strategy to combat land degradation and climate change (Lal, 2004). The quality and quantity of SOC could be improved by annual addition of organic matter (Bhattacharyya *et al.,* 2011). Labile C pools change very frequently with the soil and crop management practises; however recalcitrant SOC is protected within aggregates by long term management practices and eventually add to SOC sequestration (Lenka *et al.,* 2012). Soil aggregation trim down land degradation by shielding SOC and improving C sequestration in agro-ecosystems (Bhattacharyya *et al.,* 2013). The relative proportions of labile pools of SOC (water soluble C, microbial biomass C, and $KMnO_4$-C *etc.*) are very sensitive to management practices and suggest the suitability of management practice. Conversely, recalcitrant C is protected within the soil aggregates and consequently accounts for SOC sequestration. The information available on soil aggregate characterization is very scanty with respect to the labile and recalcitrant C pools, and the relative abundances of ^{13}C within the soil aggregates (Kocyigit & Demirci, 2012; Six & Paustian, 2014; Yu *et al.,* 2015). Further, the effect of different C pools, C sequestration rates and $\delta^{13}C$ with long-term crop productivity are inadequate.

Assessment of $\delta^{13}C$ values in different samples

The carbon isotope ratio refers to the ratio of the amounts ^{13}C to that of ^{12}C present in the sample, expressed relative to a standard known as Pee Dee Belemnite (PDB) expressed in ‰ (Cheng et al., 2011).

$$\delta^{13}C\ (‰) = \left[\frac{\left(X^h/X^l\right) sample}{\left(X^h/X^l\right) standard} - 1\right] \text{x } 1000$$

Where X is carbon, h: heavier C isotope (^{13}C), and l: lighter C isotope (^{12}C). The CO_2 samples must be analysed relative to the internal working gas standards. The carbon isotope ratios ($^{13}C/^{12}C$) are expressed as a relative values to the PDB.

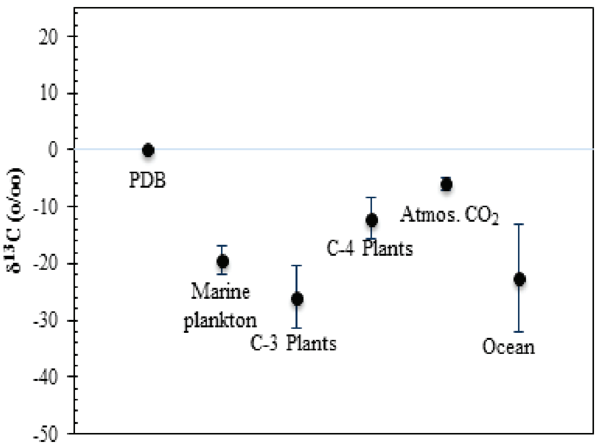


Fig. 2: The isotopic composition of different samples. Pee Dee Belemnite (PDB) is the reference standard. Error bars represents the reported range of δ13C (o/oo)

Source: Deines, 1980; Vitorello et al., 1989; Maslin and Swann, 2006.

Assessing the proportion of C derived from new residue

With help of $\delta^{13}C$ values of the SOM, it is possible to calculate the proportion of carbon derived from new residues (Balesdent and Mariotti, 1996).

$$f_{new} = \frac{\delta_{new} - \delta_{old}}{\delta_{veg} - \delta_{old}}$$

Where δ_{new} represents the $\delta^{13}C$ values of organic C in soil fractions after a period of time, δ_{old} represents the $\delta^{13}C$ values of organic C in the initial soil, i.e., the soil samples prior to tillage, and δ_{veg} represents the $\delta^{13}C$ values of the mixed samples, including plant materials and manure. Further, since we measure δ_{veg}, δ_{new} and δ_{old} independently, the standard errors associated with the proportion estimate (*f*) can be calculated through a mass-balance approach using partial derivatives (Phillips and Gregg, 2001).

$$\sigma^2 f = \left(\frac{\delta f}{\partial \delta_{veg}}\right)^2 \sigma^2 \delta_{veg} + \left(\frac{\delta f}{\partial \delta_{new}}\right)^2 \sigma^2 \delta_{new} + \left(\frac{\delta f}{\partial \delta_{old}}\right)^2 \sigma^2 \delta_{old}$$

The equation can be rearranged and reduced as;

$$\sigma^2 f = \frac{1}{(\delta_{new} - \delta_{old})^2} \left[\sigma^2 \delta_{veg} + f^2 \sigma^2 \delta_{new} + (1-f)\, \sigma^2 \delta_{old}\right]$$

Where $\sigma^2 \delta_{veg}, \sigma^2 \delta_{new}\ and\ \sigma^2 \delta_{old}$ represent the variances of the mean δ_{veg}, δ_{new} and δ_{old}, respectively. $\sigma^2 f$ represents the variance of the proportion (*f*) estimate (Dou et al., 2017).

The decay rate constant (k) for the old C present in the soil fractions (C of the organic matter before tillage) was calculated based on Cheng et al. (2011):

$$\ln (f_{old}) = - kt$$

where $f_{old} = (1 - f_{new})$ is the proportion of old C, k is the net relative decay rate constant for old C, and t is the age of the cropping treatments.

Table 1: Approaches to study soil organic matter dynamics

Sl. No.	Particulars of the study	Conclusion	Reference
1.	Link between physical soil architectural traits and organic carbon decomposition.	The functional relationship between soil physical properties with the rate of soil organic carbon decomposition within the aggregates was reported.	Li et al., 2016; Rabbi et al., 2016
2.	Turnover of organic matter in soil physical fractions during invasion of woody plant in grassland: evidence from natural ^{13}C and ^{15}N.	Higher rate of mineralization was observed in SOM associated with macro aggregate.	Liao et al., 2006
3.	C isotope analyses to assess alteration of chemically separated soil organic carbon pools under long-term fertilization.	Changes in accumulation due to shifts in crop species can be more evident in light fraction of soil organic matter.	Dou et al., 2016

4.	Dynamics and turnover of organic carbon and nitrogen in soil through the assessment of δ^{13}C and δ^{15}N changes under pasture and cropping practices.	Differential accumulation of light and heavy C isotopes by C-3 and C-4 plants.	Dalal et al., 2013
5.	Structural convergence of maize and wheat residue during two-year decomposition under different climatic conditions.	Enrichment of ^{13}C with depth of soil.	Wang *et al.,* 2012
6.	Soil organic carbon sequestration undere long-term fertilization in an Inceptisol.	Deep soil C sequestration in soybean-wheat cropping system was positively correlated with δ^{13}C value.	Ghosh *et al.,* 2018

The change in δ^{13}C values after 25 years of long-term fertilization in maize field

A case study of twenty five years of fertilization experiment in monoculture maize (*Zea mays L.*) on Typic Hapludoll of China reported by Dou et al. (2016) revealed that SOC content in the total organic C and labile carbon pools were significantly higher in MNPK (farmyard manure along with balanced inorganic fertilizers) and SNPK (corn straw residue along with balanced inorganic fertilizers) treated plots and lower in inorganic nitrogen fertilizer (IN) and balanced inorganic fertilizers (NPK) treated soils than the corresponding initial values in the surface soil. This has the implication that long-term addition of manure combined with inorganic fertilizers significantly increased SOC content. Higher soil organic carbon pool was noticed in surface (22.4±1.2 g kg^{-1}) and subsurface (21.2±.0.3 g kg^{-1}) MNPK-treated soils, than that of initial surface (16.8±1.4 g kg^{-1}) and subsurface (14.4±1.0 g kg^{-1}) soil samples, which gave evidence that SOC storage substantially increased both in the surface and subsurface layer. Higher δ^{13}C was noticed in surface (−19.7±0.4 ‰) and subsurface (−19.7±0.2 ‰) SNPK-treated soils due to a higher contribution of C-4 residues in the soil organic pools, than that of initial surface (−21.3±0.9 ‰) and subsurface (−22.2±0.6 ‰) soil samples. This was attributed to the root dominated t inputs of SOC (root biomass and exudates) and the larger corn roots were dispersed mostly in the 20–30 cm soil layer.

δ^{13}C changes under cropping systems

The clear mechanisms that resolve changes in SOC dynamics as a consequence of changes in the quantity and composition of residue inputs is not yet fully understood (Mazzilli et al., 2014; McDaniel et al., 2014). The *δ*^{13}C values varied from lower values in C-3 plants (-22 to -33‰) to higher values in C-4 plants (-9 to -16‰) (Vitorello et al., 1989). Plants fabricate organic residues with different ^{13}C/^{12}C ratios because of their differences in utilizing C isotopes, for instances *δ*^{13}C for maize residue (C-4 plant) is ~ -12‰ and *δ*^{13}C for soybean residue (C-3 plant) is ~ -28‰ (Dalal et al., 2013; Zhang et al., 2015). The relative contribution of new and old SOC can be gauged through the mass balance of C isotope contents, and thus SOM turnover time can be estimated *in-situ* (Zhang et al., 2015). The intermediate isotopic composition derived from mixed C-3 and C-4 vegetation (δ^{13}C = -18 to -21‰) permit researchers to concurrently follow the diminution in soil δ^{13}C after the introduction of C-3 plants or the enrichment following C-4 plants (Dalal et al., 2013;

Mazzilli et al., 2014). Thus, SOM physical fractionation, together with the natural abundance of stable C isotopes, can be considered as a useful approach for measuring SOM dynamics under long-term cropping systems (Wang et al., 2015). The long-standing theory imply that SOM was composed of inherently stable and chemically distinct compounds, while an emergent view confirmed that SOM accounts a continuum of intermediate and progressively decomposing organic compounds (Lehmann and Kleber, 2015).

The changes in soil physical properties were functionally related to the rate of organic carbon decomposition within aggregates (Li et al., 2016; Rabbi et al., 2016). For instance, macro aggregate associated SOM is more sensitive in response to tillage practices than that of micro aggregates (Kabiri et al., 2015) and hence greater SOM content and higher mineralization rates are frequently associated with macro aggregate fractions (Liao et al., 2006). Although light fraction usually represents a small proportion of total soil C, changes in C storage due to shift in crop species can be more evident in light fraction in contrast to bulk soil (Dou et al., 2016). Physical and chemical stabilization of organic matter occur through intra-aggregate particulate organic matter (iPOM), and mineral-associated organic matter (mSOM) represents the heavy and mineral-associated recalcitrant fractions (Mazzilli et al., 2015).

$\delta^{13}C$ changes in long-term fertilization and its relation with soil C sequestration rates

Although the ^{13}C natural abundance technique was used to study SOC dynamics, the information available on long-term fertilization effects on soil C sequestration and its relation with $\delta^{13}C$ is scanty. Significant correlation reported between $\delta^{13}C$ and the SOC sequestration rate demonstrate that $\delta^{13}C$ values could well predict the stability/recalcitrance of SOC. It was documented natural ^{13}C became more enriched at greater depths (Wang *et al.,* 2012). The depletion of ^{13}C abundance in the surface layer of soil, frequently gain new crop residues, partially indicate the trend of $\delta^{13}C$ in atmospheric CO_2 (Ghosh et al., 2018). Conversely, enrichment of ^{13}C in the sub-surface soil, which receive older SOC from surface, possibly will be due to isotopic fractionation during SOC decomposition (Wynn *et al.,* 2005) and lower sensitivity of sub-soil SOC to crop management practises (Flessa *et al.,* 2000). Depletion of ^{13}C in the surface soils of plots receiving no fertilizer or manure input could add less C inputs from plant residues than the plots receiving combined application of NPK fertilizer and manure. Enrichment of ^{13}C in the NPK fertilizer and manure treated plots in all soil layers might be due to their affluence in labile compounds (sugars and cellulose), which are rich in ^{13}C, as compared to lignin and lipids (Hobbie & Werner, 2004). Higher $\delta^{13}C$ values were also reported in macro aggregates, micro aggregates and bulk soils under NPK fertilizer plus manure treated plots signifies better stability and recalcitrance of SOC. Significant correlation between deep soil C sequestration rates and $\delta^{13}C$ was reported in soybean-wheat cropping system. NPK fertilizer along with manure application was reported surface and deep soil C sequestration with highest crop productivity (Ghosh *et al.,* 2018). Thus, $\delta^{13}C$ values are imperative to calculate C stabilization.

Conclusions

Carbon exists in different isotopic forms *viz.* ^{12}C, ^{13}C and ^{14}C and can be used as tracer to profile various ecological functions and plant adaptations. ^{13}C was less preferred by soil microbes, as compared to ^{12}C, which results in ^{13}C discrimination in soil. Assessing the amount of ^{14}C content in a dead plant or animal sample provides information that can be used to determine the age of the sample. The relative contribution of new and old SOC in cropping practice can be gauged through mass balance of C isotope contents. SOM physical fractionation, together with the natural abundance of stable C isotopes, can be considered as a useful approach to measure SOM dynamics under long-term cropping systems. Significant positive correlation reported between $\delta^{13}C$ and the SOC sequestration implies that $\delta^{13}C$ values can be used to assess the stability and recalcitrance of SOC.

References

Balesdent, J. & Mariotti, A. (1996). Measurement of soil organic matter turnover using 13C natural abundance. In: Boutton, T.W., Yamasaki, S.I.

(Eds.), Mass Spectrometry of Soils. Marcel Dekker, New York, pp. 83–111.

Bhattacharyya, R., Das, T.K., Pramanik, P., Ganeshan, V., Saad, A.A. & Sharma, A.R. (2013). Impacts of conservation agriculture on soil aggregation and aggregate-associated N under an irrigated agroecosystem of the Indo-Gangetic Plains. Nutrient Cycling in Agroecosystems, 96: 185-202.

Bhattacharyya, R., Kundu, S., Srivastva, A.K., Gupta, H.S., Ved-Prakash & Bhatt, J.C. (2011). Long term fertilization effects on soil organic carbon pools in a sandy loam soil of the Indian Himalayas. Plant and Soil, 341: 109-124.

Cheng, X., Luo, Y., Xu, X., Sherry, R. & Zhang, Q. (2011). Soil organic matter dynamics in a North America tall grass prairie after 9 yr of experimental warming. Biogeosciences, 8: 1487-1498.

Dalal, R.C., Thornton, C.M. & Cowie, B.A. (2013). Turnover of organic carbon and nitrogen in soil assessed from $\delta^{13}C$ and $\delta^{15}N$ changes under pasture and cropping practices and estimates of greenhouse gas emissions. Science of the Total Environment, 465: 26-35.

Deines, P. (1980). The isotopic composition of reduced organic carbon. In: P. Fritz and J. Ch. Fontes (Ed.). Handbook of Environmental Isotope Geochemistry, vol. 1, Elsevier, New York, pp. 329-406.

Dou, X., He, P., Cheng, X. & Zhou, W. (2016). Long-term fertilization alters chemically separated soil organic carbon pools: based on stable C isotope analyses. Scientific Reports, 6: 19061.

Dou, X., Cheng, X., He, P., Zhu, P., Zhou, W. & Wang, L. (2017). Dynamics of physically - separated soil organic carbon pools assessed from $\delta^{13}C$ changes under 25 years of cropping systems. Soil and Tillage Research, 174: 6-13.

Dou, X., He, P., Cheng, X. & Zhou, W. (2016). Long-term fertilization alters chemically separated soil organic carbon pools: based on stable C isotope analyses. Scientific Reports, 6: 19061

Flessa, H., Ludwig, B., Heil, B. & Merbach, W. (2000). The origin of soil organic C, dissolved organic C and respiration in a long-term maize experiment in Halle, Germany, determined by ^{13}C natural abundance. Journal of Plant Nutrition and Soil Science, 163: 157-163.

Ghosh, A., Bhattacharyya, R., Meena, M.C., Dwivedi, B.S., Singh, G., Agnihotri, R. & Sharma, C. (2018). Long-term fertilization effects on soil organic carbon sequestration in an Inceptisol. Soil and Tillage Research, 177: 134-144.

Hobbie, E. & Werner, R.A. (2004). Intramolecular, compound-specific, and bulk carbon isotope patterns in C3 and C4 plants: a review and synthesis. New Phytologist, 161: 371-385.

Kabiri, V., Raiesi, F. & Ghazavi, M.A. (2015). Six years of different tillage systems affected aggregate-associated SOM in a semi-arid loam soil from Central Iran. Soil and Tillage Research, 154: 114-125.

Kocyigit, R. & Demirci, S. (2012). Long-term changes of aggregate-associated and labile soil organic carbon and nitrogen after conversion from forest to grassland and cropland in northern Turkey. Land Degradation and Development, 23: 475-482.

Lal, R. (2004). Soil carbon sequestration impacts on global climate change and food security. Science, 304: 1623-1627.

Lehmann, J. & Kleber, M. (2015). The contentious nature of soil organic matter. Nature, 528: 60.

Lenka, N.K., Choudhury, P.R., Sudhishri, S., Dass, A. & Patnaik, U.S. (2012). Soil aggregation, carbon build up and root zone soil moisture in degraded sloping lands under selected agroforestry based rehabilitation systems in eastern India. Agriculture, Ecosystems and Environment, 150: 54-62.

Li, S., Gu, X., Zhuang, J., An, T., Pei, J., Xie, H., Li, H., Fu, S. & Wang, J. (2016). Distribution and storage of crop residue carbon in aggregates and its contribution to organic carbon of soil with low fertility. Soil and Tillage Research, 155: 199-206.

Liao, J.D., Boutton, T.W. & Jastrow, J.D. (2006). Organic matter turnover in soil physical fractions following woody plant invasion of grassland: evidence from natural ^{13}C and ^{15}N. Soil Biology and Biochemistry, 38: 3197-3210.

Majumder, B., Mandal, B. & Bandyopadhyay, P.K. (2008). Soil organic carbon pools and productivity in relation to nutrient management in a 20-year-old rice-berseem agroecosystem. Biology and Fertility of Soils, 44: 451-461.

Maslin, M.A. & Swann, G.E.A. (2006). Isotopes in marine sediments. In: Leng, Melanie J. (ed.). Isotopes in Palaeoenvironmental Research, Springer, Dordrecht, pp. 227.

Mazzilli, S.R., Kemanian, A.R., Ernst, O.R., Jackson, R.B. & Piñeiro, G. (2014). Priming of soil organic carbon decomposition induced by corn compared to soybean crops. Soil Biology and Biochemistry, 75:273-281.

Mazzilli, S.R., Kemanian, A.R., Ernst, O.R., Jackson, R.B. & Piñeiro, G. (2015). Greater humification of belowground than aboveground biomass carbon into particulate soil organic matter in no-till corn and soybean crops. Soil Biology and Biochemistry, 85: 22-30.

McDaniel, M.D., Grandy, A.S., Tiemann, L.K. & Weintraub, M.N. (2014). Crop rotation complexity regulates the decomposition of high and low quality residues. Soil Biology and Biochemistry, 78: 243-254.

Phillips, D.L. & Gregg, J.W. (2001). Uncertainty in source partitioning using stable isotopes. Oecologia, 127:171-179.

Qin, W., Wang, D., Guo, X., Yang, T. & Oenema, O. (2015). Productivity and sustainability of rainfed wheat-soybean system in the North China Plain: results from a long-term experiment and crop modelling. Scientific Reports, 5: 17514.

Rabbi, S.M.F., Daniel, H., Lockwood, P.V., Macdonald, C., Pereg, L., Tighe, M., Wilson, B.R. & Young, I.M. (2016). Physical soil architectural traits are functionally linked to carbon decomposition and bacterial diversity. Scientific Reports, 6: 33012.

Raj, K. K., Pandey, R.N., Singh, B. & Talukdar, A. (2019). ^{14}C labelling as a reliable technique to screen soybean genotypes (*Glycine max* (L.) Merr.) for iron deficiency tolerance. Journal of Radioanalytical Nuclear Chemistry, 322 (2): 655-662.

Raj, K. K., Pandey, R. N., Singh, B., Talukdar, A., Meena, M. C. & Chobhe K. A. (2020). Evidences for the Use of ^{14}C Content in the Root Exudates as a Novel Application of Radiocarbon Labelling for Screening Iron Deficiency Tolerance of Soybean (*Glycine max* (L.) Merr.) Genotypes. Journal of Radioanalytical Nuclear Chemistry. *https://doi.org/10.1007/s10967-020-07284-5*

Six, J. & Paustian, K. (2014). Aggregate-associated soil organic matter as an ecosystem property and a measurement tool. Soil Biology and Biochemistry, 68: A4-A9.

Tian, K., Zhao, Y., Xu, X., Hai, N., Huang, B. & Deng, W. (2015). Effects of long-term fertilization and residue management on soil organic carbon changes in paddy soils of China: a meta-analysis. Agriculture Ecosystem and Environment, 204: 40–50.

Tsipenyuk, Y. M. (1997). Nuclear Methods in Science and Technology. Institute of Physics Publishing, Bristol, UK.

Vitorello, V.A., Cerri, C.C., Andreux, F., Feller, C. & Victoria, R.L. (1989). Organic matter and natural carbon-13 distribution in forested and cultivated oxisols. Soil Sci Soc Am J 53: 773–778.

Wang, X., Sun, B., Mao, J., Sui, Y. & Cao, X. (2012). Structural convergence of maize and wheat straw during two-year decomposition under different climate conditions. Environmental Science and Technology 46: 7159-7165.

Wang, J., Wang, X., Xu, M., Feng, G., Zhang, W., Yang, X. & Huang, S. (2015). Contributions of wheat and maize residues to soil organic carbon under long-term rotation in north China. Scientific Reports, 5: 11409.

Wynn, J.G., Bird, M.I. & Wong, V.N. (2005). Rayleigh distillation and the depth profile of $^{13}C/^{12}C$ ratios of soil organic carbon from soils of disparate texture in Iron Range National Park, Far North Queensland, and Australia. Geochimica et Cosmochimica Acta, 69: 1961-1973.

Yu H, Ding W, Chen Z, Zhang H, Luo J & Bolan N. (2015). Accumulation of organic C components in soil and aggregates. Scientific Reports 5.

Zhang, K., Dang, H., Zhang, Q., Cheng, X. (2015). Soil carbon dynamics following land-use change varied with temperature and precipitation gradients: evidence from stable isotopes. Global Change Biology. *http://dx.doi.org/10.1111/gcb.12886.*

Zuazo, V.H.D. & Pleguezuelo, C.R.R. (2008). Soil-erosion and runoff prevention by plant covers: A review. Agronomy for Sustainable Development, 28: 65-86.

Received : 6th February 2020 Accepted : 4th May 2020

Prospects for Entrepreneurship Development in Integrated Farming Systems: Island Perspective

T.P.Swarnam and A.Velmurugan
ICAR- Central Island Agricultural Research Institute, Port Blair-744101
Corresponding author: swarna_8@yahoo.com

Abstract

It is essential to diversify and adopt suitable technology based on integrated farming system principles to enhance the profitability of agriculture practised by small and marginal farmers. At the same time agribusiness offers large scope for value addition, packaging, retailing, and exports of agricultural products and agricultural input and marketing with advancement in technology and IT tools. Study of constraints and opportunities in island conditions showed considerable entrepreneur opportunities through different IFS models for lowlands and hilly uplands. The diversified products from rice and coconut based farming systems enables the entrepreneur to benefit from processing and value addition besides sale of unprocessed farm produce. This also greatly enhances the stability of the farm income and sustainability of agriculture.

Key words: diversified farming, resource use, business module, income

Introduction

The opening up of Indian economy to global market during early nineties due to globalization of trade and agriculture and the policy reforms at national level, the opportunities for entrepreneurship development in agricultural sector have significantly increased. Agribusiness has offered large scope for value addition, packaging, retailing, and exports of agricultural products and agricultural input and marketing with advancement in technology and IT tools (Verma *et al*., 2019). The micro financing, relaxations in government regulations, accessibility to advanced technology, guidance and workshops on agri and allied sectors have changed the outlook of highly skilled personnel opting for self employment in agriculture, thereby increasing the entrepreneurship prospective in India (Bairwa et al., 2014). Business opportunities are available in agricultural production, agro processing and value addition, agro produce manufacturing, agricultural marketing, agro-inputs manufacturing and marketing, agro service, agro tourism etc.

In recent years emphasis is given on the start-up economy. However, a very small proportion of start-ups focus on the agricultural sector, though it plays a pivotal role in the growth and development of the Indian economy and meet the food and nutrition requirements of growing billions and creates employment opportunities for more than 53% of rural population. The disclosed investment of about $65 million was made by agri start ups in Indian agriculture in 2018, which is a 21% increase from the previous year indicating the growing opportunities in this sector. Agripreneurship is a sustainable employment strategy that will ensure self-reliance and economic self-sufficiency to the entrepreneur (Uche and Familusi, 2018). The development of agricultural entrepreneurship refers to the promotion of entrepreneurial skills amongst common individuals and building the entrepreneurial approach in the field of agriculture (Uplaonkar and Biradar, 2015).

The emphasis on cereal production over the past three decades in most developing countries has resulted in low output prices and profitability for cereals and dampened agricultural growth. To reverse this trend, one of the opportunities identified in the agricultural strategies of donor agencies is agricultural diversification. Diversification is defined as a change in business activities based on the flexible and differentiated response to changing opportunities created by new production technology or markets signals. More specifically, it is defined as a change in product choice and input use decisions based on market forces and the principles of profit maximization (Pingali 2004). At the farm level, diversification will represent a change in the underlying characteristics of the farm system such that farm practices and products are more aligned with the social, environmental, and economic contexts, as well as the constraints and opportunities that exist. The Integrated Farming System (IFS) provides a larger scope for diversification and entrepreneurship opportunities within broader scope of the sustainable development goals.

Integrated farming has been defined as the biologically IFS which: (1) integrates natural resources and regulation mechanisms into farming activities to achieve maximum replacement of off-farm inputs; (2) secures sustainable production of high quality food and other products through ecologically preferable technologies; (3) sustains farm income; (4) eliminates or reduces sources of present environment pollution generated by agriculture; and (5) sustains the multiple function of agriculture (IOBC, 1983). This section provides a glimpse of business opportunities in agriculture and allied sector in the Islands for entrepreneurship development in farming systems approach.

Methodology

Data collection

The basic data for this study was collected from two different approaches viz., farm household survey and field experiment. A farm household survey was carriedout by following stratified random sampling among the farm household in Andaman islands to collect information on farm details, inputs used, output, method of sale, income, constraint and socio-economic details. Information on integration of different farm enterprises and production of diversified products from IFS model for lowland / valley and hilly terrain was collected from the long-term ongoing field experiments on IFS under island condition. The data was compiled and economics were worked out for different IFS model and enterprises to project the entrepreneur opportunities for island condition.

Study area

The islands have 6% of geographical area under agriculture before 2004. However, 2004 Tsunami caused extensive damage to agriculture land affecting 8000ha, of which 42000 ha is permanently lost due to submergence. So at present only 4.8% of total geographical area is under agriculture. Farm diversification and landholding are considered as an important attribute of agricultural entrepreneurship as they can generally increase the net income, reduced dependence on agricultural subsidies and greater income stability (Clark, 2009). The total number of farm holdings is only 11954, having an average land holding of only 1.77 ha which is higher than national average of 1.17ha with majority of them are marginal (43%) holding having less than 1ha of land.

Rice is the main crop during wet season covering an area of 5390 ha, the area of which drastically reduced from 9000ha in 2006 due to impact of tsunami and other developmental activities especially in South Andaman region. Besides paddy common tropical vegetables are cultivated throughout the year both in wet and dry seasons. During Rabi pulses, oilseeds are also grown in the rice fallows. In Car Nicobar and Nancowry group of Islands the major land use are plantations, home gardens, natural forests and waste lands. In Great Nicobar rice and pulses are grown in coastal plains and plantations in upper slopes of hills. The North and Middle Andaman district forms the agricultural hub of the Islands, accounting for more than 50 of the agricultural production. The major crops grown in this region are food grains including rice, maize and pulses, sugarcane, fruits and vegetables and areca nut. The Nicobar region is dominated by plantation crops especially coconut, arecanut and cashew nut. The banana, pineapple, tapioca and sweet potato are grown in home gardens besides vegetables. The South Andaman district is contributing more to spices especially black pepper, clove and cinnamon mainly grown under intercropping with coconut.

Allied activities in agriculture always play a pivotal role in entrepreneurial growth and development (Chakraborty, 2014) and it has a major role in farm diversification and augmenting the income of the farmers. Differences were observed in major crops or farm animals across the island. Like crops, livestock population also varied across the district. The survey indicated the predominance of cattle, buffalo, goat population in NMA district, while

Nicobar is accounted for large population of pigs as it is an important component of tribal farming systems. The poultry especially commercial poultry is predominantly found in South Andaman because of its urban market. The kind of mixed farming is found in the islands. The crops include both seasonal and plantation crops, dairy, goat and backyard poultry are common in the rural areas of North and Middle Andaman and crops, dairy and poultry is common in the South Andaman district. Because of urbanization and increased demand from tourism sector the commercial poultry is well developed in the central zone. In Nicobar district, plantation crops (coconut) with pig and backyard poultry are the major components of farming system.

Results and discussion

Entrepreneurship opportunities

The structure of Island agriculture is undergoing transformation with the dominance of smallholders whose number has increased over time and will continue to do so in future. These farms need multienterprise farming activities that are complementary and technically compromising in the interest of the productivity of the whole farming system (Behera and France 2016). Small-size farmers can deal with issues such as under-employment and need for new jobs through entrepreneurship as opportunities exist for farmers to produce value-added agricultural products that are sold in local markets. Some of the entrepreneurial opportunities that are available in the islands are given in table 1.

Table1: Different entrepreneurship opportunities available in the Islands

District	Type of activities
Andaman Islands	• Post Harvest and Processing – Spices, coconut • Commercial Flower & Fruit Production – High value flower, fruits, vegetables – protected horticulture, vertical farming • Aromatic and Herbal Plantation- as intercrops in plantations • Dairy, Processing and Chilling • Goat farming • Broiler and Egg Production and Marketing • Carp Hatchery, crab fattening • Ornamental Fish • Agro tourism • Mushroom • Agro input marketing • Organic Farming • Mass Production of green manure seeds – *Sesbania*, sun hemp • Bio-Fertilizers Production and Marketing • Plant growth formulations – Panchakavya, bioconsortia • Vermicompost
Nicobar Islands	• Agro-based Industry – Coconut – virgin oil, coir industry, compost, charcoal making, handicrafts – coconut, shells, bamboo - Nicobar region • Major area under plantations – especially coconut • Have traditional knowledge and artisanal skill in making handicrafts from coconut shell, bamboo, pandanus leaves

These individual activities can be suitably integrated into a farming system model to diversify the agricultural production. The diversification of agricultural production system with interlinking of activities will helps in efficient resource recycling, reduce the cost of production and maximize overall farm production. It also helps in improvement in soil fertility, enhanced biodiversity conservation, imparts resilience to climatic risks and provides other environmental benefits.

Integrated Farming system for entrepreneurship development

The integrated farming system plays an important role in agricultural diversification besides improving the farm production which is found to be an alternative farm strategy for coastal plains and hilly uplands of Andaman Islands. The successful IFS models for providing entrepreneurship opportunities in the Islands are given in table 2.

Table 2: Suitable IFS models for different Physiographic locations of Andaman Island

Sl. No.	Physiography	IFS model
1	**Coastal /valley plains**	• Rice Based CS + Dairy/poultry + Fish • Rice Based CS- Mushroom • Vegetables (BBF) – fisheries – poultry • Vegetables – Fish (After Land modifications) • Mangroves- fish- mud crab fattening
2	**Uplands (Hills)**	• Coconut - fodder+ Dairy+ Goat + Fish – poultry • Coconut/ Areca nut - Spices - fodder + Livestock (goat/pig/dairy) • Coconut- fodder – dairy + organic inputs (compost/ panchkavya) • Arecanut – fodder + dairy/goat • Plantation based IFS can be converted into a agro tourism site

The establishment of farming system will be able to help the farmers for the efficient allocation of available resources in the farm and reduce the use of external inputs. With the aid of developed technology and the knowledge on the strength and are capabilities of farming system, it would be possible to provide entrepreneurial opportunities in the integrated farming systems approach. The integrated farming system plays an important role in agricultural diversification besides improving the farm production which is found to be an alternative farm strategy for coastal plains and hilly uplands of Andaman Islands (Fig. 1).

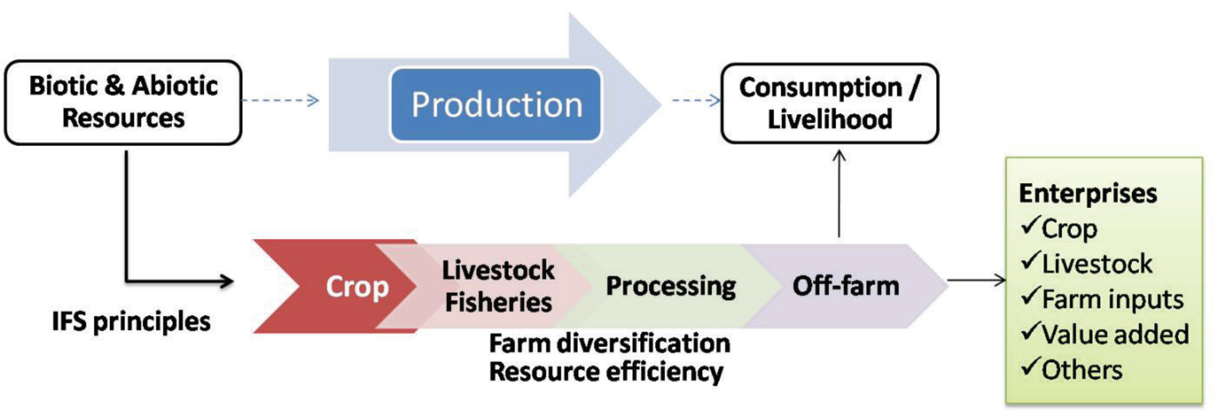


Fig 1: Role of IFS in providing entrepreneurs opportunity by diversification and resource efficiency

For the rice growing areas or lowland areas of Andaman Island a rice based farming system model was evaluated at Farmers field. In which cropping was undertaken in 0.90 ha and 0.036 ha was allocated for fishpond, poultry shed and cattle. In the IFS system a net return of Rs.1, 64,960/- was achieved as against Rs.57, 760/- from crop cultivation alone. Besides increase in farm production and productivity, it also generated employment to the tune of 239 man days year^{-1}(Ravisankar *et al*.2007).

Table 3: Production and employment opportunities in IFS

Components of IFS	Cost (Rs/ha)			Employment (Man days/ ha/year)	Farm production (MT/ha)
	Total Cost	Gross Return	Net Return		
Coastal and Valley plains					
Crop – dairy*	218500	426500	208000	352 (590/day)*	27.5
Crop – dairy-poultry-fish	99000	264900	164900	259 (636/day)	25.3
Hilly uplands					
Coconut-spices- pig-poultry cum fish	165300	394600	233300	207 (1127/day)	35.7
Areca nut + black pepper – coconut + fodder – livestock + poultry	157000	552000	394000	438 (900/day)	34.5

* per day net return or remuneration

An another IFS model involving crops + dairy based farming system in an area of 0.75ha with crops, vegetables, dairy and fishery recorded a net return of 2.08 lakhs with productivity of 27.5 MT and generation of employment 352 man days per year (Swarnam et al.). This could give a daily emolument of Rs.590 to Rs.1137 per day depending on the system which is much higher than the payment in other unorganised or services sector. Rice straw is the major farm waste mushroom cultivation can be integrated in the above systems as a subsidiary activity for further enhancing the farm income. In uplands coconut/arecanut with dairy/goat or poultry integrated into a system has greater potential for increasing farm income with less manpower or labour requirement than more intensive systems.

Constraints for entrepreneurial development in the Islands

Farming is a challenging livelihood option in India, especially in the Island region. Though agricultural and allied sector provides vast scope for entrepreneurial opportunities in the islands, they have to overcome many constraints to be successful entrepreneurs. It includes

1. Majority of the farmers are marginal and small holders and agriculture is largely a means of livelihood for them. The capital required for development of the farms into a business house is huge for them and organizations feel risk in making heavy investments and implementing modern technologies in agriculture which affect the profitability. Thus, resultant farmer members lose interest in their own enterprises.
2. Lack of hard work as the farmers want easy money without hard work. The present day youth is interested to work in service sectors (hotel, tourism, travels etc.) instead of working on their own farm even if they are underpaid.
3. Except few commodities most of the agricultural produce is imported from the mainland. This may affect the competitive advantage of the local produce and the farmers finally loss their interest.

4. The islands are scattered, remote and lack transportation facilities to reach out the market.
5. Lack of storage facilities and lack of capital for investment in agribusiness opportunities

Conclusions

Agri-entrepreneurship is need of the hour to make agriculture more attractive and profitable business enterprise for empowering the rural unemployed youth when other sector failed to provide employment opportunities. In the Islands agriculture and allied sector has good scope for entrepreneurship which can be harnessed by effective management of natural resources, agro inputs on the farm to meet the market demand. The constraints such as lack of financial capital, lack of hard work among farmers, non remunerative prices, lack of agro inputs, and market linkages has to be addressed for making agriculture as an avenue for business development. With proper training, formation of farmers producers organizations, increased government lending and development of infrastructural facilities for storage, promotion of farmers market and market intelligence by exploiting the IT tools will play a significant role in promoting entrepreneurship development in the Islands for growing household incomes. The good managerial skills and entrepreneurial expertise infuse with government measures would facilitate accomplishment of the growing needs of agri-business.

References

Bairwa S L, Kalia A, Meena L K, Lakra K & Kushwaha S. 2014. Agribusiness management education: a review on employment opportunities. International Journal of Scientific and Research Publications. 4(2): 1-4.

Behera U.K. & France J. 2016. Integrated Farming Systems and the Livelihood Security of Small and Marginal Farmers in India and Other Developing Countries. Advance in Agronomy, 138: 235-282.

Chakraborty, D. 2014. Rural entrepreneurship development efforts-a study on entrepreneurial growth with special reference to Sonitpur District of Assam. Assam University, Diphu Campus.

Clark, J. 2009. Entrepreneurship and diversification on English farms: identifying business enterprise characteristics and change processes. Entrepreneurship and Regional Development, 21(2): 213–236.

IOBC, 1983. International Organization for Biological and Integrated Control. Technical bulletin 16:1

Pingali, P.L. 2004. Agricultural diversification: Opportunities and constraints. *In Proceedings of the FAO Rice Conference*, *Food and Agricultural Organization of United Nations.* Italy: Rome.

Ravisankar N, Pramanik S C, Jeyakumar S, Singh D R, Nabisat Bibi, Shakila Nawaz & Tapan Kumar Biswas.2007. Study on Integrated Farming System (IFS) under different resource conditions of island ecosystem. *Journal of Farming System Research & Development* 13 (1): 1-9.

Swarnam, T.P., Velmurugan A, Subramani T., Swain S, Perumal P, Jaisankar I & Pandey S.K.2018. Integrated farming system for enhancing farm income in rainfed lowlands of Andaman islands. J. Andaman Science Association 23(2): 106-109

Uche, C., & Familusi, L. (2018). The adoption of agripreneurship as a mitigating measure to unemployment in Nigeria: a topical review. Global Journal of Management and Business Research, 18(2), 25–31

Uplaonkar, S. S., & Biradar, S. S. (2015). Development of agriculture in India through agripreneurs. International Journal of Applied Research, 1(9), 1063–1066

Verma M, Arya L, Kashyap P & Tyagi R 2019. Scope and Importance of Agri-Entrepreneurship. In: Agri-Entrepreneurship: Challenges and Opportunities (eds. Kashyap et al.). Today and Tomorrow's Printers and Publishers, New Delhi.pp:1-22

World Bank 2012. World Bank. 2012. World Development Report 2013: Jobs. World Bank, Washington, DC.

Received : 14th February Accepted : 21st April

Annotated Checklist of Pyraloid Moths (Lepidoptera: Pyraloidea) of Andaman and Nicobar Islands

B. Sumit Kumar Rao* and C. Sivaperuman
Zoological Survey of India, Andaman Nicobar Regional Center, Port Blair-744101
Corresponding author: sumitkumarb3850@gmail.com

Abstract

This paper presents an annotated checklist of Pyraloidea Moths from Andaman and Nicobar Islands with 202 species including 180 Crambidae and 22 Pyralidae. Of the recorded species, 180 species reported from Andaman group of islands and 57 from Nicobar group of islands. Twenty-five species are common to both islands group. The subfamily Spilomelinae showed highest number of species (140 species; 69 %) followed by Pyraustinae (19 species; 9%). Crambinae, Glaphyriinae, Galleriinae showed lowest species richness.

Keywords: Pyraloidea, Pyralidae, Crambidae, Andaman & Nicobar Islands, Micor lepidoptera

Introduction

The Pyraloidea, comprising the families Pyralidae and Crambidae are one of the mega-diverse super families of Lepidoptera, with about 16,000 described species worldwide, with greatest richness in the tropics (van Nieukerken *et al.,* 2011; Solis *et al.,* 2007; Regier *et al.,* 2012). Larvae of pyraloids cause major damage of crops worldwide (Clausen, 1978). Species of several subfamilies are pests to the crops, stored foodstuffs, forests and ornamental plants, defoliate shrubs and fruit trees. Only few species are directly benefiting humans as a biological control agent (Zhang, 1994; Center *et al*., 2002). It is necessary to understand the geographical distribution of this economically important group.

Andaman and Nicobar Islands situated at Bay of Bengal, around 1200 km from mainland India between 6° - 14° N latitudes and 92° - 94° E latitudes, consist of around 572 islands and are known for its rich biodiversity. Lepidopteran fauna of these archipelagos are well documented by various workers in the past. However, Micro-lepidoptera of these islands receives very less attention. In this paper, we presented an annotated checklist of superfamily Pyraloidea of Andaman and Nicobar Islands with 202 species including 180 Crambidae and 22 Pyralidae based on available literature and field studies.

The Pioneer work on the Pyraloid fauna of Andaman and Nicobars carried by Moore (1877), who gave an extensive account of the Pyralids moths of South Andaman and Nicobar Islands. Cotes and Swinhoe (1889) recorded several Pyraloids in their catalogue of Indian moths. Hampson (1896, 1898) described and reported several Crambids and Pyralids in publication of Fauna of British India. Swinhoe (1906, 1907) described two more new species with three new records to India and two Crambids from and Andaman and Nicobar Islands respectively. Bhattacharya and Mandal (1976) and Bhattachrya (1977) recorded *Terastia meticulosalis* Guenee from Car Nicobar and *Xanthomelaena schematias* (Meyrick) from Great Nicobar respectively. Mandal and Bhattacharya (1980) reported 57 species under 30 genera from Andamans, and 14 species and 9 genera from Nicobars and only one species from Great Nicobar.

Abbas and Gangwar (1983), Jainath and Gangwar (1984), Shah and Belvadi (1985a), have also supplemented our knowledge on moths of agricultural importance of these Islands. Das *et al.,* (1987) reared larvae *of Hymenoptychis sordida* Zeller, 1852 from the infested fruits of mangroves belonging to *Bruguiera gymnorhyza* and *Sonneratia abla* and the stems of *Acanthus ilicifolius.* Das *et al.,* (1988) reported larvae of *Hypsipyla robusta* (Moore, 1886) boring the mangrove *xylocarpus granatum.* Bhumannavar (1989) recorded *Orthaga exvinaea* Hampson and *Autocharis albizonalis* (Hampson) from Mango (fruit crop) in South Andaman. Bhumannavar (1990) reported caterpillers and adults of *cirrhohrista fumipalpis* from a wild fig *Fius hispida* in South Andaman. Bhumannavar and Jacob (1990) recorded *Tirathaba* *mundella* Walker as a fruit borer of mango in South Andaman for the first time. Shah (1990) studied reaction of wild rice, *Oryza indandamania* Ellis to rice leaf folder *Canaphalorosis medinalis* Guenee and Rice Case worm *Nymphula depunctalis* Guenee. Bhumannavar (1991a,) and Bhumannavar (1991b) recorded Seven pyralide from agricultural weeds in south Andaman and a new record of *Citripestis eutraphera* Meyrick on *Mangifera andamanica* Respectively. Bhumannavar (1992) reported four pyralids from pulses and vegetable crops in South Andaman. Veenakumari and Mohanraj (1994) reported defoliation of *Tabernaemontana divarticata* by larvae of *Parotis vertumnalis* (Guenee).

Chandra and Kumar (1992) provided a comprehensive checklist of 415 species of moths from these islands which accounted for 134 species of Pyraloids. Chandra (1993, 1994, 1996, 1997) latter added few more species to the existing list of pyraloids. Rao *et al.,* (1994) reported six species of Pyraloids from the North Reef Island Wildlife Sanctuary, Veenakumari (1995) recorded *Hellula undalis* (F.) on Radish and Cole crops and *Leucinodes orbonalis* (G.) on Brinjal. Veenakumari and Mohanraj (1996) also added two more Crambids to the existing list. Chandra and Rajan, (1995, 2004) provided a checklist of Moths of Mount Harriet National Park which is also included number of species from this superfamily. Jacob *et al.,* (2004) also recorded *Citripestis eutraphera* as pests of cashew in Sippighat Area. Veenakumari and Mohanraj (2009) reported 14 species of Pyraloides on Mangrove associates in the Andaman Islands. Sivaperuman *et al.,(*2012) and Sivaperuman and Shah (2012a, b; 2013) further added new records from this islands. Chandra (2017) also provided a comprehensive list of moths of Great Nicobar Island of including 55 species of Crambidae. The most recent literature on the Lepidoptera fauna of these islands is provided by Chandra *et al.,* (2018) with around 165 species of pyraloids

Methods

The present paper was prepared based on the field studies in A & N Islands and consulted all available literature on the lepidopteran fauna. The classification system followed by van Nieukerken *et al.,* (2011) was updated using GLOBIZ database. The geographic distribution and key references of the cited literatures were also provided.

Result and discussion

A total of 202 species of Pyraloids moths were reported from Andaman and Nicobar Islands which includes 180 species of Crambidae and 22 species of Pyralidae, belonging to 11 Sub-families (Table 1). Of which 180 species were recorded from Andaman group of islands and 57 were recorded from Nicobar group of islands. These two group of islands shares 25 species in common occurrence. Among all Lepidoptera, Pyraloids shows the most diverse living habits, the larvae of most of the species are pest, some live parasitically in the nest of ants or bees. Some larvae are adapted to live under water and some are adapted to dry environments (Nuss *et al*., 2003-2020). Graphical representation of the diversity from the recorded Sub-families is presented in Fig. 2. The Spilomelinae with 3,500 species distributed worldwide among Pyraloids (Minet, 1981; Solis and Maes, 2003; Regier *et al.,* 2012), about 140 Species (69 %) from Andaman and Nicobar Islands followed by Pyraustinae (19; 9%). Crambinae, Glaphyriinae, Galleriinae were the least specious Sub-families. High species diversity of the Pyraloids is probably due to the undisturbed tropical forests of this archipelago.

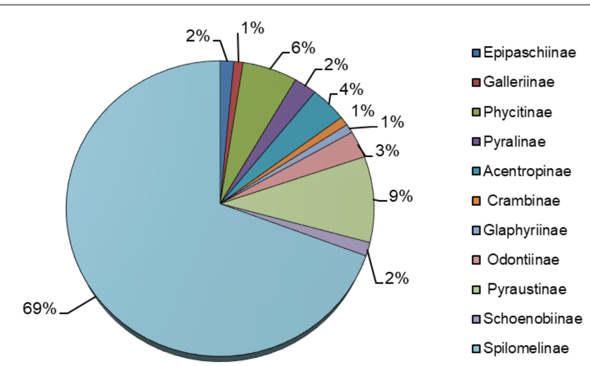


Fig. 1. Diversity of species from the reported Sub-Familes

Literatures reviews shows that most of the survey conducted in the past were limited only to the South Andaman, Middle Andaman, Car Nicobar, Kamorta and Great Nicobar Islands, thus excluding many other islands and their unexplored habitat. Pyraloids are best represented at lower and middle elevations in Tropics (Munroe and Solis, 1999). Long term intensive and extensive surveys needs to be carried out in all type of forests including agricultural ecosystems for the better understanding of the diversity in this group.

Table 1: Annotated Checklist of Pyraloidea from Andaman and Nicobar Islands

Sl. No.	Species Name	AN	NI	Reference
1	Superfamily Pyraloidea			
2	Family Pyralidae Latreille, 1809			
3	Sub Epipaschiinae Meyrick, 1884			
4	*Lepidogma ambifaria* (Hering, 1901)	√	-	Chandra *et at.*, 2018
5	*Locastra muscosalis* (Walker, [1866])	√	-	Chandra *et at.*, 2018
6	*Orthaga exvinacea* (Hampson, 1891)	√	-	Chandra *et at.*, 1992
7	Sub Family Galleriinae Zeller, 1848	-	-	
8	*Aphomia cephalonica*(Stainton, 1866)	√	-	Chandra *et at.*, 2018
9	*Tirathaba mundella* Walker, 1864	√	-	Bhumannavar & Jacob (1990)
10	Sub Family Phycitinae Zeller, 1839			
11	*Assar* sp.	√	-	Chandra *et at.,* 2018
12	*Cadra cautella* (Walker, 1863)	√	-	Chandra *et at.,* 2018
13	*Cathylia fulvella* Ragonot , 1888	√	-	Veenakumari *et al.,*1997
14	*Citripestis eutraphera* (Meyrick, 1933)	√	-	Bhumannavar, 1992
15	*Copamyntis obliquifasciella* (Hampson, 1896)	√	-	Chandra and Kumar, 1992
16	*Emmalocera nigricostalis* (Walker, 1863)	√	-	Chandra and Kumar, 1992
17	*Epicrocis oegnusalis* (Walker, 1859)	√	-	Chandra *et al.,*2018
18	*Etiella zinckenella* (Treitschke, 1832)	√	-	Chandra and Kumar, 1992
19	*Hypsipyla robusta* (Moore, 1886)	√	-	Das *et al.,* (1988)
20	*Mascelia sp.nr, ectophoea* Hampson, 1908	√	-	Veenakumari *et al.,*1997
21	*Phycita clientella* (Zeller, 1867)	√	-	Chandra, 1992
22	*Thylacoptila paurosema* Meyrick, 1885	√	-	Chandra, 2018
23	Sub Family Pyralinae Latreille, 1809			
24	*Hypsopygia nigrivitta* (Walker, 1863)	√	-	Veenakumari *et al*., 1997
25	*Macna platychloralis* (Walker, [1866])	√	-	Hampson, 1896
26	*Pyralis trifascialis* Moore, 1877	√	-	Moore, 1877
27	*Vitessa nicobarica* Hampson, 1896	-	√	Hampson, 1896
28	*Vitessa suradeva* Moore, [1860]	√	-	Hampson, 1896
29	Family Crambidae Latreille, 1810			
30	Sub Family Acentropinae Stephens, 1836			
31	*Eristena oligostigmalis* Hampson, 1906	√	-	Hampson 1906
32	*Eristena parvalis* (Moore, 1877)	√	-	Moore, 1877; Cotes and Swinhoe (1889)

Sl. No.	Species Name	AN	NI	Reference
33	*Opisthedeicta poritialis* (Walker, 1859)	√	-	Veenakumari and Mohanraj, 2009
34	*Parapoynx stagnalis* (Zeller, 1852)	√	-	Chandra *et al*.,2018
35	*Parapoynx affinialis* Guenée, 1854	√	√	Chandra *et al*.,2018; Hampson, 1986
36	*Parapoynx diminutalis* (Snellen, 1880)	√	-	Chandra and Rajan, 1995
37	*Parapoynx fluctuosalis* (Zeller, 1852)	√	-	Chandra *et al*.,2018
38	*Strepsinoma croesusalis* (Walker, 1859)	√	-	Chandra *et al*.,2018
39	Sub Family Crambinae Latreille, 1810			
40	*Ancylolomia chrysographellus* (Kollar, 1844)	√	-	Khan, 2000
41	*Chilo sacchariphagus indicus* (Kapur, 1950)	√	-	Chandra *et al*., 2018
42	Sub Family Glaphyriinae W. T. M. Forbes, 1923			
43	*Hellula undalis* (Fabricius, 1781)	√	-	Chandra and Kumar, 1992
44	*Noorda blitealis* Walker, 1859	√	-	Chandra *et al.,*2018
45	Sub Family Odontiinae Guenée, 1854			
46	*Balaenifrons* sp.	√	-	Chandra *et al*.,2018
47	*Dausara marginalis* Moore, [1877]	√	-	Moore, 1877
48	*Dausara talliusalis* Walker, 1859	√	-	Mandal and Bhattachrya, 1980
49	*Deanolis sublimbalis* (Hampson, 1903)	√	-	Chandra and Kumar, 1992; Chandra *et al.,* 2018
50	*Hyalinarcha hyalinalis* (Hampson, 1896)	√	-	Mandal and Bhattacharya, 1980
51	*Taurometopa aryostrota* (Hampson, 1917)	√	-	Veenakumari *et al.,*1997
52	Sub Family Pyraustinae Meyrick, 1890			
53	*Calamochrous homochroalis* Swinhoe, 1907	√	-	Swinhoe, 1907
54	*Tetridia vinacealis* (Moore, 1877)	√	-	Moore, 1877; Cotes and Swinhoe, 1889
55	*Chobera althealis* (Walker, 1859)	√	-	Hampson, 1896
56	*Chobera cascale* (Swinhoe, 1890)	√	-	Mandal and Bhattacharya, 1980
57	*Crypsiptya coclesalis* (Walker, 1859)	√	-	Khan, 2000
58	*Euclasta* sp.	√	-	Veenakumari and Mohanraj, 2009
59	*Isocentris filalis* (Guenée, 1854)	-	√	Mandal and Bhattacharya, 1980
60	*Limbobotys limbolalis* (Moore, 1877)	√	-	Moore, 1877
61	*Limbobotys ptyophora* (Hampson, 1896)	√	-	Chandra *et al.,* 2018
62	*Loxoneptera albicostalis* Swinhoe, 1906	√	-	Mandal and Bhattacharya, 1980
63	*Loxostege perbonalis* (Swinhoe, 1890)	√	-	Veenakumari & Mohanraj, 2009
64	*Pagyda discolor* Swinhoe, 1894	√	√	Mandal and Bhattacharya, 1980
65	*Pagyda salvalis* Walker, 1859	√	-	Mandal and Bhattacharya, 1980

Sl. No.	Species Name	AN	NI	Reference
66	*Paliga damastesalis* (Walker, 1859)	√	-	Veenakumari and Mohanraj, 1996
67	*Prooedema inscisalis* (Walker, 1866)	√	√	Chandra, 1996
68	*Pyrausta sikkima* Moore, 1888	√	-	Hampson 1896; Chandra, 1992
69	*Pyrausta tetraplagalis* Hampson, 1899	-	√	Mandal and Bhattacharya, 1980
70	*Spinosuncus aureolalis*(Lederer, 1863)	√	-	Moore, 1877; Hampson, 1896
71	*Ostrinia furnacalis* (Guenée, 1854)	√	-	Mandal and Bhattacharya, 1980
72	Sub Family Schoenobiinae Duponchel, 1846			
73	*Scirpophaga incertulas* (Walker, 1863)	-	√	Chandra, 1992
74	*Scirpophaga innotata* (Walker, 1863)	√	-	Chandra *et al.,*2018
75	*Scirpophaga nivella* (Fabricius, 1794)	√	-	Chandra *et al.,*2018
76	Sub Family Spilomelinae Guenée, 1854	-	-	
77	*Aetholix flavibasalis* (Guenee, 1854)	√	√	Hampson, 1896; Mandal and Bhattacharya, 1980
78	*Agrotera nemoralis* (Scopoli, 1763)	-	√	Sivaperuman *et al.,*2012
79	*Agrotera scissalis* Walker, 1865	√	-	Chandra and Rajan, 1995
80	*Agathodes ostentalis* Hubner, 1937	√	-	Hampson, 1896
81	*Agrioglypta itysalis* (Walker, 1859)	√	-	Hampson, 1896
82	*Antigastra catalaunalis* (Duponchel, 1833)	√	-	Mandal and Bhattacharya, 1980
83	*Ategumia adipalis* (Lederer, 1863)	√	-	Moore, 1877; Hampson, 1896
84	*Bacotoma cuprealis* (Moore, 1877)	√	-	Moore, 1877
85	*Blepharomastix hedychroalis* Swinhoe, 1907	√	-	Swinhoe, 1907; Hampson, 1908
86	*Bradina admixtalis* Walker, 1859	√	-	Zakir khan, 2000
87	*Chabula telphusalis* (Walker, 1859)	-	√	Chandra, 1996
88	*Chalcidoptera emissalis* (Walker, 1866)	√	√	Chandra, 1994
89	*Chrrhochrista brizoalis* (Walker, 1859)	√	√	Chandra, 1996
90	*Cirrhochrista fumipalpis* Felder, 1874	√	√	Chandra and Kumar, 1992
91	*Cnaphalocrocis bilinealis* (Hampson, 1891)	√	√	Mandal and Bhattacharya, 1980
92	*Cnaphalocrocis medinalis* (Guenée, 1854)	√	√	Mandal and Bhattacharya, 1980
93	*Cnaphalocrocis patnalis* (Bradley, 1981)	√	-	Chandra *et al*., 2018
94	*Conogethes pandamalis* (Walker, 1859)	-	√	Mandal and Bhattacharya, 1980
95	*Coptobasis fraterna* (Moore, 1885)	-	√	Mandal and Bhattacharya, 1980
96	*Cydalima laticostalis* (Guenée, 1854)	√	-	Moore 1877; Hampson, 1896
97	*Cydalima pfeifferae* (Lederer, 1863)	√	√	Mandal and Bhattacharya, 1980
98	*Diaphania glauculalis* (Guenée, 1854)	-	√	Mandal and Bhattacharya, 1980
99	*Diaphania indica* (Saunders, 1851)	√	√	Mandal and Bhattacharya, 1980
100	*Diasemia accalis* (Walker, 1859)	√	-	Kendrick, 2002
101	*Dichocrocis atrisectalis* Hampson, 1908	√	-	Hampson, 1908

Sl. No.	Species Name	AN	NI	Reference
102	*Dichocrocis frenatalis* Lederer, 1863	-	√	Lederer, 1863; Moore, 1877
103	*Endocrossis flavibasalis* (Moore, 1867)	√	√	Chandra, 2017
104	*Eurrhyparodes tricoloralis* (Zeller, 1852)	√	-	Mandal and Bhattacharya, 1980
105	*Filodes fulvidorsalis* (Geyer in Hübner, 1832)	-	√	Chandra *et al*., 2018
106	*Filodes mirificalis* (Lederer, 1863)	√	√	Moore, 1877; Cotes and Swinhoe, 1889
107	*Gadessa nilusalis* (Walker, 1859)	√	-	Mandal and Bhattacharya, 1980
108	*Glyphodes actorionalis* Walker, 1859	√	√	Moore 1877; Mandal and Bhattacharya, 1980
109	*Glyphodes bicolo*r (Swainson, 1821)	-	√	Mandal and Bhattacharya, 1980
110	*Glyphodes bivitralis* Guenée, 1854	√	√	Mandal and Bhattacharya, 1980
111	*Glyphodes caesalis* Walker, 1859	√	-	Cotes and Swinhoe, 1889
112	*Glyphodes canthusalis* Walker, 1859	√	-	Chandra *et al*., 2018
113	*Glyphodes ernalis* Swinhoe, 1894	√	-	Veenaumari and Mohanraj, 2009
114	*Glyphodes stolalis* Guenee, 1854	√	√	Chandra *et al*., 2018
115	*Goniorhynchus plumbeizonalis* Hampson, 1896	√	-	Mandal and Bhattacharya, 1980
116	*Haritalodes derogata* (Fabricius, 1775)	√	√	Moore, 1877; Mandal and Bhattacharya, 1980
117	*Herpetogramma bipunctalis* (Fabricius, 1794)	√	-	Chandra, 1992
118	*Herpetogramma licarsisalis* (Walker, 1859)	√	-	Moore, 1877; Mandal and Bhattacharya, 1980
119	*Herpetogramma luctuosalis* (Guenee, 1854)	√	-	Moore, 1877
120	*Herpetogramma mutualis* Zeller, 1852	√	-	Cotes and Swinhoe, 1889
121	*Herpetogramma phaeopteralis* (Guenée, 1854)	√	-	Mandal and Bhattacharya, 1980
122	*Herpetogramma platycapna* (Meyrick, 1897)	√	-	Moore, 1877
123	*Herpetogramma stultalis* (Walker, 1859)	√	-	Hampson, 1896
124	*Heterocnephes lymphatalis* (Swinhoe, 1889)	-	√	Chandra, 1994
125	*Hydriris ornatalis* (Duponchel, 1832)	√	-	Chandra *et al.,* 2018
126	*Hymenia perspectalis* (Hübner, 1796)	√	-	Mandal and Bhattacharya, 1980
127	*Hymenoptychis sordida* Zeller, 1852	√	-	Das *et al*., 1987
128	*Indogrammodes pectinicornalis* (Guenée, 1854)	√	-	Mandal and Bhattacharya, 1980
129	*Ischnurges gratiosalis* (Walker, 1859)	√	√	Mandal and Bhattacharya, 1980
130	*Lamprosema niphealis* Walker, 1859	√	√	Hampson, 1896; Chandra *et al.,*2018
131	*Lepidoneura longipalpis* (Swinhoe, 1894)	√	-	Veenkumari and Mohanraj, 2009
132	*Leucinodes orbonalis* Guenée, 1854	√	-	Moore, 1877; Hampson, 1896
133	*Mabra eryxalis* (Walker, 1859)	√	-	Chandra *et al.,* 2018

Sl. No.	Species Name	AN	NI	Reference
134	*Marasmia poeyalis* (Boisduval, 1833)	√	-	Khan, 2000
135	*Maruca amboinalis* (Felder, Felder & Rogenhofer, 1875)	√	√	Chandra *et al.,* 2018
136	*Maruca vitrata* (Fabricius, 1787)	√	√	Mandal and Bhattacharya, 1980
137	*Messepha absolutalis* Walker, 1859	√	-	Chandra and Kumar, 1992
138	*Metoeca foedalis* (Guenée, 1854)	√	-	Chandra *et al.,* 2018
139	*Nacoleia charesalis* (Walker, 1859)	√	-	Mandal and Bhattacharya, 1980
140	*Nacoleia insolitalis* (Walker, 1862)	-	√	Hampson, 1896
141	*Nankogobinda artificalis* (Lederer, 1863)	√	-	Cotes and Swinhoe, 1889
142	*Nausinoe geometralis* (Guenée, 1854)	√	-	Mandal and Bhattacharya, 1980
143	*Nausinoe perspectata (Fabricius, 1775)*	√	-	Chandra *et al.,* 2018
144	*Nevirina procopia* (Stoll in Cramer & Stoll, 1781)	√	-	Chandra, 1994
145	*Nosophora incomitata* (Swinhoe, 1894)	√	√	Chandra and Kumar 1992, Chandra, 1996
146	*Nosophora quadrisignata* Moore, 1884	√	-	Cotes and Swinhoe, 1889
147	*Notarcha obrinusalis* (Walker, 1859)	√	√	Hamspon, 1896; Cotes and Swinhoe, 1889
148	*Omiodes analis* (Snellen, 1880)	√	-	Veenakumari and Mohanraj, 2009
149	*Omiodes diemenalis* (Guenée, 1854)	√	√	Hampson, 1896; Mandal and Bhattacharya, 1980
150	*Omiodes indicata* (Fabricius, 1775)	√	-	Chandra, 1992
151	*Omiodes longipennis* (Warren, 1896)	√	-	Chandra *et al.,*2018
152	*Omiodes origoalis* (Walker, 1859)	-	√	Hampson, 1908; Chandra and Kumar 1992
153	*Omiodes ovenalis S*winhoe, 1906	√	-	Swinhoe, 1906
154	*Omiodes surrectalis* (Walker, 1866)	√	-	Veenakumari and Mohanraj, 2009
155	*Omphisa anastomosalis* (Guenée, 1854)	√	-	Hampson, 1899
156	*Omphisa illisalis* (Walker, 1859)	√	-	Moore, 1877;
157	*Orphanostigma abruptalis* (Walker, 1859)	√	√	Cotes and Swinhoe, 1889; Mandal and Bhattacharya, 1980
158	*Orphnophanes thoasalis* (Walker, 1859)	√	-	Moore, 1877
159	*Orthospila plutusalis* (Walker, 1859)	√	-	Hampson, 1896
160	*Pachynoa grossalis* (Guenée, 1854)	√	-	Swinhoe, 1906
161	*Pachynoa thoosalis* (Walker, 1859)	√	-	Hampson, 1896
162	*Palpita ardealis* (C. Felder, R. Felder & Rogenhofer, 1875)	√	√	Moore, 1877; Cotes and Swinhoe, 1889
163	*Palpita celsalis* (Walker, 1859)	-	√	Mandal and Bhattacharya, 1980
164	*Palpita nigropunctalis* (Brem, 1864)	√	-	Mandal and Bhattacharya, 1980

Sl. No.	Species Name	AN	NI	Reference
165	*Palpita picticostalis* (Hampson, 1896)	√	-	Hampson, 1896
166	*Palpita rhodocosta* Inoue, 1997	√	-	Sivaperuman and Shah 2012b
167	*Pardomima amyntusalis* (Walker, 1859)	√	-	Hampson, 1896
168	*Pardomima amyntusalis* Walker (1859)	√	-	Cotes and Swinhoe, 1889
169	*Parotis marginata* (Hampson, 1893)	√	√	Hampson, 1896; Chandra and Kumar, 1992
170	*Parotis marinata* (Fabricius, 1784)	√	-	Mandal and Bhattacharya, 1980
171	*Parotis suralis* (Lederer, 1863)	-	√	Mandal and Bhattacharya, 1980
172	*Parotis vertumnalis* (Guenée, 1854)	√	√	Mandal and Bhattacharya, 1980
173	*Patania balteata* Fabricius, 1798	√	-	Veenakumari *et al*., 1997, Chandra 2017
174	*Patania caletoralis* (Walker, 1859)	√	-	Hampson, 1896
175	*Patania imbecilis* (Moore, 1888)	√	-	Mandal and Bhattacharya, 1980
176	*Patania iopasalis* (Walker, 1859)	√	-	Hampson, 1896
177	*Patania scinisalis* (Walker, 1859)	√	-	Moore, 1877; Cotes and Swinhoe, 1889
178	*Phostria crithonalis* (Walker, 1859)	√	-	Chandra and Kumar, 1992
179	*Phostria maculicostalis* (Hampson, 1893)	√	-	Mandal and Bhattacharya, 1980
180	*Phostria origoalis* Walker, 1859	-	√	Swinhoe, 1906
181	*Phostria radicalis* (Walker, 1866)	√	-	Swinhoe, 1906
182	*Phostria schediusalis* (Walker, 1859)	-	√	Mandal and Bhattacharya, 1980
183	*Phostria unitalis* (Guenée, 1854)	√	-	Moore, 1877
184	*Phryganodes eradicalis* Hampson, 1908	√	√	Moore, 1877; Hampson, 1908
185	*Physematia concordalis* Lederer, 1863	√	√	Moore, 1877; Cotes and Swinhoe, 1889
186	*Piletocera aegimiusalis* (Walker, 1859)	√	-	Chandra and Kumar, 1992
187	*Poliobotys ablactalis* (Walker, 1859c)	√	-	Kirti *et al.,* 2016
188	*Polygrammodes sabelialis* (Guenée, 1854)	√	-	Hampson, 1896
189	*Pramadea crotonalis* (Walker, 1859)	√	-	Mandal and Bhattacharya, 1980
190	*Pramadea denticulata* Moore, 1888	√	-	Chandra, 1992
191	*Pramadea lunalis* (Guenée, 1854)	√	-	Moore, 1877; Hampson, 1896
192	*Prophantis octoguttalis* (C. Felder, R. Felder & Rogenhofer, 1875)	√	√	Mandal and Bhattacharya, 1980
193	*Pycnarmon aeriferalis* (Moore 1877)	√	-	Moore, 1877
194	*Pycnarmon alboflavalis* (Moore, 1888)	√	-	Hampson, 1898
195	*Pycnarmon jaguaralis* (Guenée, 1854)	√	-	Chandra *et al.,* 2018
196	*Pycnarmon meritalis* (Walker, 1859)	-	√	Mandal and Bhattacharya, 1980
197	*Pycnarmon obinusalis* (Walker, 1859)	-	√	Moore, 1877
198	*Pygospila tyres* (Cramer, 1779)	√	-	Chandra and Rajan, 2004

Sl. No.	Species Name	AN	NI	Reference
199	*Rehimena surusalis* (Walker, 1859)	√	-	Veenakumari and Mohanraj, 2009
200	*Rehimena villalis* Swinhoe, 1906	√	-	Swinhoe, 1906
201	*Rhimphalea ochalis* (Walker, 1859)	√	-	Mandal and Bhattacharya, 1980
202	*Rhimphalea trogusalis* (Walker, 1859)	√	-	Chandra and Kumar, 1992;
203	*Rhimphaleodes macrostigma* Hampson, 1893	√	-	Chandra and Rajan, 1995
204	*Samba purpurascens* Moore, 1877	√	-	Moore, 1877; Cotes and Swinhoe, 1889
205	*Samea castoralis* (Walker, 1859)	√	-	Hampsom, 1896
206	*Sameodes cancellalis* (Zeller, 1852)	√	-	Mandal and Bhattacharya, 1980
207	*Spoladea recurvalis* (Fabricius, 1775)	√	√	Mandal and Bhattacharya, 1980
208	*Syllepte distinguenda* E. Hering, 1901	√	-	Veenakumari and Mohanraj, 1996
209	*Syllepte sellalis* (Guenee, 1854)	√	-	Hampsom, 1896
210	*Synclera traducalis* (Zeller, 1852)	-	√	Mandal and Bhattacharya, 1980
211	*Syngamia latimarginalis* (Walker, 1859)	√	-	Mandal and Bhattacharya, 1980
212	*Talanga sexpunctalis* (Walker, 1877)	√	√	Moore, 1877
213	*Terastia meticulosalis* Guenee, 1854	√	√	Bhattachary and Mandal (1976)
214	*Tyspanodes linealis* (Moore, 1867)	√	-	Moore, 1877
215	*Xanthomelaena schematias* (Meyrick, 1894)	√	√	Bhattacharya (1977); Mandal and Bhattachrya, 1980
216	*Zagiridia noctualis* Hampson, 1897	√	-	Veenakumari *et al.,*1997

Table 2: List of few Synonyms/ Misapplied names

Sl. No	Updated taxa	Synonym/ Misapplied names	References
1	*Deanolis sublimbalis* Snellen, 1899	*Autocharis albizonalis* (Hampson, 1903)	Chandra and Kumar, 1992; Chandra *et al*., 2018
2	*Spinosuncus aureolalis* (Lederer, 1863)	*Pyralis ochrealis* Moore, 1877	Moore, 1877; Hampson, 1896
3	*Scirpophaga nivella* (Fabricius, 1794)	*Scirpophaga chrysorrhoa* (Zeller, 1863)	Chandra *et al*., 2018
4	*Herpetogramma licarsisalis* (Walker, 1859)	*Botys abstrusalis* Walker, 1859; *Botys immundalis* Walker, 1866	Moore, 1877; Mandal and Bhattacharya, 1980
5	*Nankogobinda artificalis* (Lederer, 1863)	*Samea inscitalis* Walker, 1865	Cotes and Swinhoe, 1889
6	*Nausinoe perspectata* (Fabricius, 1775)	*Nausinoe pueritia* (Cramer, [1780])	Chandra *et al*., 2018
7	*Orthospila plutusalis* (Walker, 1859)	*Pycnarmon discinotalis* Moore, 1877	Hampson, 1896

Sl. No	Updated taxa	Synonym/ Misapplied names	References
8	*Parotis marinata* (Fabricius, 1784)	*Pachyarches maliferalis* Walker, 1866	Moore, 1877; Mandal and Bhattacharya, 1980
9	*Phostria unitalis* (Guenée, 1854)	*Botys opalinalis* Moore, 1877	Moore, 1877

Acknowledgements

Authors are thankful to Dr. Kailash Chandra, Director, Zoological Survey of India for his encouragement and support.

References

Abbas, S.R. & Gangwar, B. (1983). Management of Insect pests of paddy in Andamans. *Farmers and Parliament*. 18: 20–30.

Bhattacharya, D.P. (1977). On *Xantholnelaena schematias* (Meyrick) (Lepidoptera Pyralidae) - a new record from Great Nicobar Island, India. *Newsl. Zool. Surv. India*. **3**(5): 258.

Bhattacharya, D.P. & Mandal, D.K. (1976). A new record of Terastia meticulosalis Guenée (Lepidoptera: Pyralidae) from the Gt. Nicobar Island. *Newsletter Zoological Survey of India*, 2(1), 23-24.

Bhumannavar, B.S. (1989). New records of insect pests on fruit crops in South Andaman. *Journal of the Andaman Science Association*, 5(2), 127-131.

Bhumannavar, B.S. (1990). Further new records of insect pests on fruit crops in South Andaman. *Journal of the Andaman Science Association*, 6(2), 122-126.

Bhumannavar, B.S. (1991a). Phytophagous insects on weeds in South Andaman. *Journal of Andaman Science Association.* **7**(1): 53–61.

Bhumannavar, B.S. (1991b). Record of *Citripestis eutraphera* Meyrick (Pyralidae: Lepidoptera) on Mangifera andamanica in India. *Journal of the Bombay Natural History Society*, 88(2), 299.

Bhumannavar, B.S. (1992). Further new records of insect pests on pulse and vegetable crops in South Andaman. *Journal of the Andaman Science Association*, 8(1/2), 74-78.

Bhumannavar, B.S., & Jacob, T.K. (1990). *Tirathaba mundella* Walker (Pyralidae: Lepidoptera) a new fruit borer of mango in south Andaman (India). *Entomon*, 15(3-4), 286-287.

Center, T.D., Dray, F.A. Jr., Jubinsky, G.P. & Grodowitz, M.J. (2002). Insects and other arthropods that feed on aquatic and wetland plants. USDA, ARS *Technical Bulletin*, 1870, 1–20

Chandra, K. & Rajan, P.T. (1995). Moths of Mount Harriet National Park, Andaman. *Journal of Andaman Science Association*, 11(1), 71-75.

Chandra, K. (1993). New records of moths of Bay Islands. *Journal of Andaman Science Association*, 9(1&2), 44-49.

Chandra, K. (1994). Further new records of moths from Andaman and Nicobar Islands. *Journal of Andaman Science Association*, 10(1&2), 17-24.

Chandra, K. (1996). Moths of Great Nicobar Biosphere Reserve, *India. Malayan Nature Journal*, 50, 107-108.

Chandra, K. (1997). New additions to the moth fauna of Andaman and Nicobar Islands. *Journal of Andaman Science Association*, 13(1), 44-47.

Chandra, K. (2017). Faunal diversity of the Great Nicobar Biosphere Reserve. *Conservation Area Series*. **61**: 159-167 (Published by the Director, *Zool. Surv. India,* Kolkata)

Chandra, K. & Kumar, S. (1992). Moths (Heterocera: Lepidoptera) of Andaman and Nicobar Islands. *Journal of Andaman Science Association*, 8(2), 138-145.

Chandra, K., & Rajan, P.T. (2004). Faunal diversity of Mount Harriet National Park (South Andaman). *Zoological Survey of India*.

Chandra, K., Gupta, D., Kushwaha, S., Das, P., & Ghosh, J. (2018). Arthropoda: Hexapoda. Faunal Diversity of Biogeographic Zones: Islands of India, 247-320.

Clausen, C. P. (1978). Introduced parasites and predators of arthropod pests and weeds: a world review. Curculionidae. US Department of Agriculture *Agriculture Handbook*, 259-276480.

Cotes, E.C. & Swinhoe, C. (1889). A Catalogue of the Moths of India, Part 5. Pyrales.

Das, A. K., Dev Roy, M.K. & Mitra, B. 1988. Insect borers of mangroves in the Bay islands. *Journal of Andaman Science Association*, *4*, 32-38.

Das, A. K., Dev Roy, M. K. & Mitra, B. (1987). Some moth borers of mangroves in the Andaman Islands. *Journal of the Andaman Science Association,* 3(2), 140-142.

Hampson, G.F. (1896). The fauna of British India, including Ceylon and Burma: Moths. Vol IV. Taylor and Francis, London. 594 p

Hampson, G.F. (1898). A Revision of the Moths of the Subfamily Pyraustinae. Part I. *Proceedings of the Zoological Society of London.* 590-761, pIs. 49, *50.*

Hampson, G. F. (1908). The moths of India. Supplementary paper to the volumes in "The fauna of British India." Series III, Part XI. – *The Journal of the Bombay Natural History Society*. 18, 572–585.

Jacob, T. K., Veenakumari, K. & Bhumannavar, B.S. (2004). Insect pests of cashew in the Andaman Islands. *Cashew*, 18(4), 25-28.

Jainath, & Gangwar, B. (1984). Identification of major insect pest and disease problems of paddy in Andamans. *Seeds and Farms*. 9: 17–22.

Kendrick, R.C. (2002). Moths (Insecta : Lepidoptera) of Hong Kong. (Thesis). University of Hong Kong, Pokfulam, Hong Kong SAR. Retrieved from http://dx.doi.org/10.5353/th_b3027883

Khan, Z. H. (2000). Biosystematic studies on Pyralid Pest of rice crop in India (Pyralidae: Lepidoptera). (Thesis). Aligarh Muslim University, Aligarh.

Kirti, J. S., Singh, N., & Singh, H. (2016). Inventory of subfamily Pyraustinae (Crambidae: Lepidoptera) from Sikkim. *Journal of Entomology and Zoology Studies*. 4(6): 700-705

Kirti, J. S., Singh, N., & Singh, H. (2016). Inventory of subfamily Pyraustinae (Crambidae: Lepidoptera) from Sikkim. *Journal of Entomology and Zoology Studies*, 4(6), 700-705.

Mandal, D.K., & Bhattacharya, (1980). On the Pyraustinae (Lepidoptera: Pyralidae) from the Andaman, Nicobar and Great Nicobar Islands, Indian ocean. *Rec. zool. Surv. India*, 77, 293-342.

Minet, J., (1981). Les Pyraloidea et leurs principales divisions systématiques [Lep. Ditrysia]. Bulletin de la Société entomologique de France, 86(9), pp.262-280.

Moore, F. 1877. Lepidopterous fauna of the Andaman and Nicobar Islands. *Proceedings of the Zoological Society of London.* 580–632.

Munroe, E. & Solis, M.A. (1999). Pyraloidea. Lepidoptera, Moths and Butterflies, Vol. 1,Arthropoda, Insecta, Vol. 4, Part 35, Handbook of Zoology (ed. by N. Kristensen), pp. 233–256, 491 pp. Walter de Gruyter and Co, Berlin

Nuss, M., Landry, B., Mally, R., Vegliante, F., Tränkner, A., Bauer, F., Hayden, J., Segerer, A., Schouten, R., Li, H. & Trofimova, T., (2003-2020). Global Information System on Pyraloidea. World Wide Web electronic publication: www. pyraloidea. Org.

Rao, G C., Rao, D.V., & Devi, K. (1994). A faunal exploration of the North reef Island sanctuary, North Andaman. *Journal of the Andaman Science Association*. Port Blair, 10(1), 68-81.

Regier, J. C., Mitter, C., Solis, M. A., Hayden, J. E., Landry, B., Nuss, M., ... & Cummings, M. P. (2012). A molecular phylogeny for the pyraloid moths (Lepidoptera: Pyraloidea) and its implications for higher-level classification. Systematic Entomology, 37(4), 635-656.

Shah, N.K. & Belvadi, V.V. (1985a). Insect pests of Agri-horticultural and plantation crops in Andaman. *Annual Report, CARI*. **1**: 62–63.

Shah, N. K. (1990). Reaction of wild rice, *Oryza indandamanica* Ellis to leaf folder and case worm. *Journal of the Andaman Science Association*, 6(2). 171

Sivaperuman, C., Shah, S.K., Raghunathan, C., Chandra, K. & Venkataraman, K. (2012). Nine New Records of Moth from Andaman and Nicobar Islands. *Biological-Forum An International Journal*, **4** (1): 23–26.

Sivaperuman, C., & Shah, S. K. (2012a). Diversity of moths in Great Nicobar Biosphere Reserve (GNBR), Andaman and Nicobar Islands. *Biological Forum - An International Journal*. **4**(1): 54–60.

Sivaperuman, C., & Shah, S.K. (2012b). Diversity of moths in Neil Island, Andaman and Nicobar Islands. *Biological Forum - An International Journal*, **4**(1): 61–64.

Sivaperuman, C. & Shah, S.K. (2013). Observations on Moths of Baratang Island, Andaman and Nicobar Archipelago. *The Journal of Tropical Asian Entomology*, **2**(1): 28–36

Solis, M.A. & Maes, K.V.N. (2003). Preliminary phylogenetic analysis of the subfamilies of Crambidae (Pyraloidea Lepidoptera), *Belgian Journal of Entomology*, Bruxelles 4(2002): 53-95.

Solis, M.A. (2007). Phylogenetic studies and modern classification of the Pyraloidea (Lepidoptera). Revista Colombiana de Entomología. 33:1-8.

Swinhoe, C. (1906). XXXVI. New and little-known species of Heterocera from the East. *Journal of Natural History*, 17(99), 283-297.

Swinhoe, C. (1907). XXIV. New species of Eastern and African Heterocera. *Journal of Natural History*, 19(111), 201-208.

Van Nieukerken, E. J., Kaila, L., Kitching, I. J., Kristensen, N. P., Lees, D. C., Minet, J., & Wahlberg, N. (2011). Order Lepidoptera Linnaeus, 1758. In: Zhang, Z.-Q. (Ed.) Animal biodiversity: an outline of higher-level classification and survey of taxonomic richness. Zootaxa, 3148(1), 212-221.

Moore, F. (1877). Lepidopterous fauna of the Andaman and Nicobar slands. *Proceedings of the Zoological Society of London.* 580–632.

Veenakumari, K. & Mohanraj, P. (1996). Folivorous insects damaging teak, Tectona grandis L.(Verbenaceae) in the Andaman Islands, Bay of Bengal, Indian Ocean. *Journal of Entomological Research*, 20(2), 177-178.

Veenakumari, K., Mohanraj, P. & Bandyopadhyay, A.K., (1997). Insect herbivores and their Natural Enemies in the Mangals of the Andaman and Nicobar Islands. *Journal of Natural History*, 31(7), 1105-1126.

Veenakumari, K. & Mohanraj, P. (2009). A note on the entomofauna of mangrove associates in the Andaman Islands (Indian Ocean: India). *Journal of Natural History*, 43(13-14), 807-823.

Veenakumari, K., & Mohanraj, P. (1994). Insect pests of ornamental plants in Andaman and Nicobar Islands. *Journal of Andaman Science Association*, 10 (1 and 2): 25-27

Veenakumari, K., Mohanraj, P., & Ranganath, H. R. (1995). Additional records of insect pests of vegetables in the Andaman Islands (India). *Journal of Entomological Research*, 19(3), 277-279.

Zhang, B. C. (1994). Index of Economically Important Lepidoptera. CAB International, Wallingford, Oxon.

Received : 14th February 2020 Accepted : 4th May 2020

Butterflies of Andaman and Nicobar Islands: An Updated Checklist

Sant Kumar* **and C. Sivaperuman**
Zoological Survey of India, Andaman and Nicobar Regional Centre, Port Blair - 744 102, Andaman & Nicobar Islands, India
**Corresponding author: snkr2012@gmail.com*

Abstract

The Andaman and Nicobar Islands is a part of the two biodiversity hotspots represents highly diverse fauna and endemism. An extensive field surveys were carried out during 2008 through 2020 in various parts of Islands from Landfall island of North Andaman to Southernmost island of Great Nicobar. This paper prepared based on the field observation and also consulted available literature to prepare the updated checklist. A total of 304 species and subspecies of butterflies were reported from Andaman and Nicobar Islands.

Introduction

Butterflies are one of the best-known groups of insects and play a major role in the ecosystems functioning, including pollinations, nutrient cycling, environment health, insect-plant interactions, and climate change (Sparrow *et al.,* 1994; Hill *et al*., 1995; Beccaloni and Gaston, 1995; Schulze and Fielder, 1998; Wood and Gillman, 1998). Tropical butterflies are not just as a potential biological indicator, but represent some of the most spectacular and visually appealing organisms in the world and play many vital roles in tropical ecosystems (Bonebrake *et al*., 2010; Schulze *et al*., 2010 and De Vries *et al.*, 2012). Butterflies are one of the important indicators of biodiversity, which is often used for monitoring the ecosystem response to environmental changes (Kunte, 1999; Kocher and Williams, 2000). There are about 18,500 species of butterflies found throughout the world out of which 1,318 species of Butterflies are distributed in the Indian region (Varshney and Smetacek, 2015). Many butterfly species are strictly seasonal and prefer only a particular set of habitats as they are highly sensitive to changes in temperature, humidity, and light; parameters that are easily influenced by habitat deterioration (Kunte, 1997 and Murphy *et al.,*1990).

An attempt was made to compile the available information and provide an updated checklist of butterflies from these islands. The present paper deals with a total of 304 species/subspecies based on extensive field surveys and available literature. The first paper on the butterflies was published by Atkinson (1874), who describes two endemic species from Andaman followed by Hewitson (1874) who has provided the first list of 41 species of butterfly from Andaman. Later, Moore (1877) updated the list of 105 butterflies of which 78 were recorded from Andaman and 33 from Nicobar. Wood-Mason and De Niceville (1880, 1881a, 1881b, 1882) raised the list up to 160. Evans (1932) provided comprehensive keys to the butterflies of the India region and raised the list to 191 species from the islands. Major additions of butterflies were largely based on the collection of Ferrar who was the Chief Commissioner of these islands for a period of 8 years (1923 to 1931). In his paper, Ferrar (1948) deals with the 268 forms of butterflies and described 133 species. Later, many researchers have contributed on the butterfly diversity of Andaman and Nicobar islands (Vane-Wright, 1993; Arora and Nandi, 1980, 1982; Chaturvedi, 1982; Khatri, 1989, 1991, 1992, 1993; Khatri and Singh, 1988; Khatri and Mitra, 1989a,b; Veenakumari and Mohanraj 1991, 1996; Chaturvedi and Hussain, 1991; Chandra and Khatri, 1995; Davidar *et al*., 2010; Chandra and Rajan, 1996; Mohanraj and Veenakumari, 1996; Veenakumari *et al.,* 1997; Devy *et al*., 1994, 1998; Sivaperuman *et al*., 2010, 2011, 2012, 2014, 2016; Simhachalam, *et al*., 2017).

But only a few researchers have added to the existing list namely, *Delias hyparete* (Linnaeus, 1758) and *Erionota thrax thrax*to (Khatri and Singh, 1987 and Prashanth Mohanraj and Veenakumari, 1991). Khatri (1989; 1993) made an attempt to update the checklist of butterfly, and reported 214 species and 236 subspecies in 116 genera belonging to five families and three subfamilies.

Prashanth Mohanraj and Veenakumari (2011) provided a comprehensive checklist of 218 species and segregate species that are stragglers, as well as those which have been erroneously reported from these islands. Varshney and Smetacek (2015) provided a synoptic catalogue of the butterflies of India, where they deal with 274 species/subspecies. Apart from the contribution in the checklist of butterflies, many other researchers have contributed to the diversity of butterflies in Andaman and Nicobar Islands.

Study area

The Andaman and Nicobar Islands are situated in the Bay of Bengal between 6° to 14° North latitudes and 92° to 94° East longitudes with 572 islands along with islets and rocky outcrops. These islands are divided into the Andaman group and Nicobar group with a total land area of 8249 km^2 which are separated by the ten-degree channel which is about 150 km wide 400 fathoms deep.

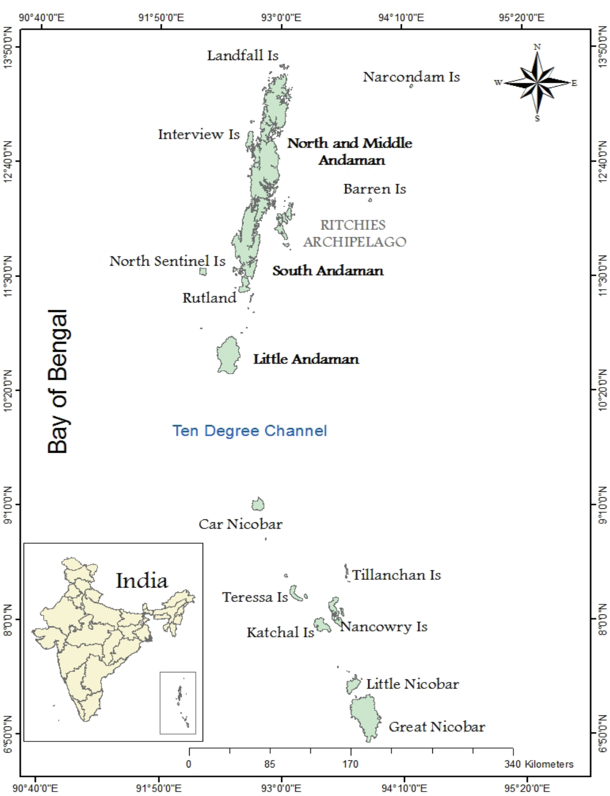


Fig. 1. Map of Andaman and Nicobar Islands

Andaman and Nicobar Islands is one of the major bio-geographical zones of India which is covered by 81.74% of forest cover (FSI, 2019). Of these, 5,677.52 km^2 is very dense forest, 683.89^2 km is moderately dense forest (MDF), and 381.52 km is under open forests. The forest cover has increased by 0.78^2 km as compared with the previous year report of 2017 (FSI, 2019). The northern tip of Andaman is 190 km away from Myanmar while, the southern tip of Nicobar is 150 km off the coast of Sumatra, Indonesia. The biota shares a close affinity with Indo-Burmese and Indo-Malayan in the Andaman and Nicobar than mainland India. The climate is tropical humid weather having two main seasons. The average temperature ranges from a minimum of 26°C to a maximum of 32°C with relative humidity 70-98% and prolongs the rainy season lasts for about 180 days (May-December) ranges from 3000 to 3300 mm per year when the island is visited by both the Southwest and the Northeast monsoons.

Methods

The study was carried out from 2008 to 2020 in the various parts of the islands. Butterflies were observed by line transect methods by Pollard (1977) and Pollard and Yates (1993) for a distance of 600 mt during morning hours from 06.00 am to 11.00 am. Identification of butterflies was made with the help of field guides and reference books (Kehimker, 2016; Evans, 1932; Ferrar, 1948).

Results and discussion

A total of 304 species and subspecies of butterflies is listed, under 145 genera and six families from Andaman and Nicobar Islands. Among the families, Nymphalidae has the highest number of butterfly species (99 Species; 32.57%), followed by Lycaenidae (98 species; 32.24%), Hesperridae (55 species; 18.09%), Pieridae (30 species; 9.87%), Papilionidae (21 species; 6.91%), while Riodinidae recorded only one species from Andaman Islands. The most diverse genus is *Euploea* with 15 subspecies (5.26%), followed by *Nacaduba* (11 subspecies; 3.62%), *Jamides* (10 subspecies; 3.29%) and *Arhopala* (8 subspecies; 2.30%). A total 176 species/subspecies endemic butterflies were recorded from different groups of Islands. The Andaman group constitutes 209 species of butterflies while Nicobar constitutes 147 and 52 were common in both the groups (Table 1).

Table. 1: Occurrence of butterfly in Andaman and Nicobar Islands

	Andaman groups	Nicobar groups	Both groups
Nymphalidae	63	46	10
Papilionidae	12	10	2
Pieridae	18	19	6
Lycaenidae	69	47	18
Hesperiidae	46	25	16
Riodinidae	1	-	-
	209	147	52

Fifteen species of butterflies were endemic to these Islands, of which, 12 are exclusively endemic to Andaman Islands namely, Andaman Swallowtail *Graphium epaminondes,* Andaman Clubtail *Losaria rhodifer,* Andaman Mormon *Papilio mayo,* Color Sergeant *Athyma nefte,* Andaman Viscount *Tanaecia cibaritis,* Andaman Crow, *Euploea andamanensis*, White Oakleaf *Kallima albofasciata,* Andamanese Eyed Bushbrown *Mycalesis radza,* Andaman Palmking *Amathusia andamanensis,* Andaman Tailless Oakblue *Arhopala zeta,* Andaman Violet Onyx *Horaga albimacula* and Andman Great Orange Tip *Hebomoia roepstorfii* and three are from Nicobar islands such as Nicobar Yeoman *Cirrochroa nicobarica*, Nicobar Map *Cyrestis tabula* and Nicobarese Blind Bushbrown *Mycalesis manii*. Recent molecular phylogeny studies by Wei *et al*. (2017) revealed that species *cottonis* to the genus *Elymnias* have been synonymise and these taxa are placed under the subspecies of *hypermnestra*. Similarly, Andaman Nawab *Charaxes andamanicus* (Fruhstorfer, 1906) was treated as a subspecies of *Charaxes athamas andamanicus* (Fruhstorfer, 1906) but, based on the recent molecular work by Toussaint *et al*. (2015) the species *athamas* has species complicity now it is treated as a distinct species (Table 2).

Table 2. Recent changes in the taxonomic classification of Butterflies

Sl. No.	Scientific Name	Current Nomenclature	References
1	*Polyura athamas andamanicus*(Fruhstorfer, 1906)	*Charaxes andamanicus* (Fruhstorfer, 1906)	Toussaint *et al*., (2015)
2	*Polyura schreiber tisamenus* (Fruhstorfer, 1914)	*Charaxes schreiber tisamenus* (Fruhstorfer, 1914)	Toussaint *et al*., (2015)
3	*Elymnias cottonis cottonis* (Hewitson, 1874)	*Elymnias hypermnestra cottonis* (Hewitson, 1874)	Wei *et al*., 2017
4	*Elymnias cottonis jennifferae* Suzuki, 2006	*Elymnias hypermnestra jennifferae* Suzuki, 2006	Wei *et al*., 2017
5	*Euthalia teuta teutoides* (Moore, 1877)	*Bassarona teuta teutoides* (Moore, 1877)	Kunte *et al*., 2020
6	*Lethe europa tamuna* de Niceville, 1887	*Lethe tamuna* de-Niceville, 1887	Kunte *et al*., 2020

7	*Appias libythea olferna* Swinhoe, 1890	*Appias olferna* Swinhoe, 1890	Kunte *et al*., 2020
8	*Appias paulina galathea* (C. & R. Felder, [1865]	*Appias galathea* (C. & R. Felder, [1865])	Kunte *et al*., 2020
9	*Erionota hiraca hiraca* (Moore, 1881)	*Erionota acroleuca* (Wood-Mason & De Niceville, 1881)	Xue and Lo 2015

Of the recorded species, a total of 68 species and subspecies of butterflies were protected under Schedule I, II and IV of the Indian Wildlife (Protection) Act, 1972, (Anon., 2014) (Table 1). Seventeen species were designated under Schedule I, 45 species are under schedule II and 6 species were included in Schedule IV.

Acknowledgements: We would like to thanks Dr. Kailash Chandra, Director, Zoological Survey of India, Kolkata for providing necessary support. We express our sincere thanks to the Principal Chief Conservator of Forest (PCCF), Department of Environment and Forests, Andaman and Nicobar Islands for logistic support to carry out the studies in various parts of the islands.

Table 3: Updated checklist of Butterflies from Andaman and Nicobar Islands

Sl. No.	Common Name	Scientific name	WPA	Distribution	
				AI	NI
	Nymphalidae				
1	Oriental Banded Yeoman	*Algia fasciata fasciata* (C. & R. Felder, 1860)	I		✓
2	Andaman Palm king	*Amathusia andamanensis* Fruhstorfer, 1899	II	✓	
3	Andaman Sergeant	*Athyma rufula* de Niceville, [1889]		✓	
4	Andaman Banded Marquis	*Bassarona teuta teutoides* (Moore, 1877)	II	✓	
5	Andaman Red Lacewing	*Cethosia biblis andamanica* Stichel, 1902		✓	
6	Nicobar Red Lacewing	*Cethosia biblis nicobarica* (C. Felder, 1862)			✓
7	Bengal Leopard Lacewing	*Cethosia cyane* (Drury, [1773])			
8	Andaman Nawab	*Charaxes andamanicus* (Fruhstorfer, 1906)	II	✓	
9	Andaman Twany Raja	*Charaxes bernardus agna* Moore, 1878		✓	
10	Variable Tawny Rajah	*Charaxes bernardus hierax* C. & R. Felder, [1867]		✓	
11	Nicobar Yeoman	*Cirrochroa nicobarica* (Wood Mason & de Niceville, 1881)			✓
12	Andaman Common Yeoman	*Cirrochroa tyche anjira* Moore, 1877		✓	
13	Andaman Rustic	*Cupha erymanthis andamanica* Moore, [1900]		✓	
15	Nicobar Rustic	*Cupha erymanthis nicobarica* (C. Felder, 1862)			✓
16	Thai Marbled Map	*Cyrestis cocles cocles* (Fabricius, 1787)	II	✓	
17	Nicobar Map	*Cyrestis tabula* deNiceville, 1883			✓

Sl. No.	Common Name	Scientific name	WPA	Distribution	
				AI	NI
18	Andaman Map Butterfly	*Cyrestis thyodamas andamanica* Wood-Mason & de Niceville, 1881		✓	
19	Oriental Plain Tiger	*Danaus chrysippus chrysippus* (Linnaeus, 1758)		✓	✓
20	Striped Tiger	*Danaus genutia genutia* (Cramer, [1779])		✓	✓
21	Camorta White Tiger	*Danaus melanippus camorta*(Evans, 1932)			✓
22	White Tiger	*Danaus melanippius nessipus* (C. Felder, 1862)			✓
23	Malaya Tiger	*Danaus affinis malayana* (Fruhstorfer, 1899)			✓
24	Andaman Great Duffer	*Discophora timora andamensis* Staudinger, 1887	II	✓	
25	Andaman Great Duffer	*Doleschallia bisaltide andamanensis* Fruhstorfer, 1899	I	✓	
26	Palmfly	*Elymnias hypermnestra jennifferae* Suzuki, 2006		✓	
27	Andaman Palm fly	*Elymnias hypermnestra cottonis* (Hewitson, 1874)		✓	
28	Nicobar Studded Palmfly	*Elymnias panther mimus* Wood Mason & de Niceville, 1881			✓
29	Andaman Crow	*Euploea andamanensis* Atkinson, [1874]		✓	
30	Little Andaman Crow	*Euploea andamanensis bumila* Evans, 1932: 10A		✓	
31	Sentinel Andaman Crow	*Euploea andamanensis ferrari* Tytler, 1939		✓	
32	Camorta Spotted Crow	*Euploea crameri biseriata (Moore, 1883)*			✓
33	Car Nicobar Spotted Crow	*Euploea crameri esperi* C. Felder, 1862			✓
34	Spotted Black Crow	*Euploea crameri frauenfeldii* C. Felder, 1862			✓
35	Blue Banded Crow	*Euploea eunice novarae* C. Felder, 1862			✓
36	Plain Blue Crow	*Euploea modestamodesta* Butler, 1866			
37	Blue Spotted Crow	*Euploea midamus chloe* (Guerin-Meneville, 1843)			✓
38	Andaman Spotted Crow	*Euploea midamus roepstorffi* (Moore, 1883)		✓	
39	Striped Blue Crow	*Euploea mulciber mulciber* (Cramer, [1777])	IV	✓	
40	Great Crow	*Euploea phaenareta castelnaui* C & R Felder, [1865]			✓
41	Camorta Cinnamon Crow	*Euploea scherzericamorta* Moore, 1877			✓
42	Great Nicobar Cinnamon Crow	*Euploea scherzerisimulatrix* Wood-Mason & de Niceville,1881			✓

Sl. No.	Common Name	Scientific name	WPA	Distribution	
				AI	NI
43	Car Nicobar Cinnamon Crow	*Euploea scherzerischerzeri* C. Felder, 1862			✓
44	Double Banded Crow	*Euploea sylvester harrisii,* C. & R. Felder, [1865]		✓	
45	Painted Courtesan	*Euripus consimilis consimilis* (Westwood, 1850)	II	✓	
46	Andaman Baron	*Euthalia acontius* (Hewitson, 1874)	II	✓	
47	Malayan Eggfly	*Hypolimnas anomala* (Wallace, 1869)			✓
48	Great Egg fly	*Hypolimnus bolina jacintha* (Drury, 1773)		✓	✓
49	Danaid Eggfly	*Hypolimnus misippus* (Linnaeus, 1764)	I	✓	✓
50	Andaman Pasha	*Herona marathus andamana* Moore, 1877	II	✓	
51	Andaman Tree Nymph	*Idea agamarschana cadelli* (Wood Mason & de Niceville, 1880)		✓	
52	Grey Glassy Tiger	*Ideopsis juventa nicobarica* (Wood Mason & de Niceville, 1881)			✓
53	Oriental Peacock Pansy	*Junonia almana* (Linnaeus, 1758)		✓	✓
54	Nicobar Peacock Pansy	*Junonia almana nicobariensis* (C. Felder, 1862)			✓
55	Oriental Grey Pansy	*Junonia atlites* (Linnaeus, 1763)		✓	✓
56	Oriental Yellow Pansy	*Junonia hierta magna* (Evans, 1926)		✓	
57	Chinese Lemon Pansy	*Junonia lemonias lemonias* (Linnaeus, 1758)		✓	
58	Blue pansy	*Junonia orithya ocyale* Huebner, [1819]			✓
59	Andaman White Oakleaf	*Kallima albofasciata* Moore, 1877	II	✓	
60	Andaman Banded Dandy	*Laringa horsfieldi andamanensis* de Niceville, 1895		✓	
61	Tiger Lascar	*Lasippa monata monata* (Weyenbergh, 1874)			✓
62	Yellow Jack Sailer	*Lasippa viraja nar* (de Niceville, 1891)		✓	
63	Andaman Bamboo Treebrown	*Lethe europa nudgara* Fruhstorfer, 1911		✓	
64	Clear-eyed Treebrown	*Lethe tamuna* de-Niceville, 1887	I		✓
65	Oriental Common Evening Brown	*Melanitis leda leda* (Linnaeus, 1758)		✓	✓
66	Andaman Great Evening Brown	*Melanitis zitenius andamanica* Evans, 1923	II	✓	
67	Andaman Commander	*Moduza procris anarta* (Moore, 1877)		✓	
68	Nicobarese Blind Bushbrown	*Mycalesis manii* Doherty, 1886			✓

Sl. No.	Common Name	Scientific name	WPA	Distribution	
				AI	NI
69	Chinese Dark Branded Bushbrown	*Mycalesis mineus mineus* (Linnaeus, 1758)		✓	
70	Nicobar Dark-brand Bushbrown	*Mycalesis mineus nicobarica* (Moore 1890)			✓
71	Common Bushbrown	*Mycalesis perseus cepheus* Butler, 1867		✓	
72	Andamanese Eyed Bushbrown	*Mycalesis radza* Moore, 1877		✓	
73	Andaman Long banded Bush brown	*Mycalesis visala andamana* (Moore, [1892])		✓	
74	Andaman Sullied Sailer	*Neptis clinia clinia* Moore, 1872		✓	
75	Andaman Common Sailer	*Neptis hylas andamana* Moore, 1877		✓	
76	Nicobar Common Sailer	*Neptis hylas nicobarica* Moore, 1877			✓
77	South Nicobar Common Sailer	*Neptis hylas sambilangsa* (Evans, 1932)			✓
78	Andaman Chestnut Streaked Sailer	*Neptis Jumbah amorosca* Fruhstorfer, 1905		✓	
79	Andaman Clear Sailer	*Neptis nata evansi* Eliot 1969		✓	
80	Common Medus Brown	*Orsotriaena medus medus* Evans, 1932		✓	
81	Nicobar Medus Brown	*Orsotriaena medus nicobarica* Evans, 1932			✓
82	White Banded Lascar	*Pantoporia cnacalis* (Hewitson, 1874)		✓	
83	Extra Lascar	*Pantoporia sandaca ferrari* Eliot, 1969		✓	
84	Andaman Glassy Tiger	*Parantica aglea melanoleuca* (Moore, 1877)		✓	
85	Dark Glassy Tiger	*Parantica agleoides agleoides* (C & R. Felder, 1860)			✓
86	Chocolate Tiger	*Parantica melaneus plataniston* (Fruhstorfer, 1910)			✓
87	Nicobar Clipper	*Parthenos sylvia nila* (Evans, 1932)	II		✓
88	Andaman Clipper	*Parthenos sylvia roepstorfii* Moore, [1897]	II	✓	
89	Short Banded Sailer	*Phaedyma columella binghami* Fruhstorfer, 1905			✓
90	Andaman Small Leopard	*Phalanta alcippe andamana* (Fruhstorfer, 1904)	II	✓	
91	Nicobar Small Leopard	*Phalanta alcippe fraterna* Moore, 1900			✓
92	Oriental common Leopard	*Phalanta phalantha phalantha* (Drury, [1773])		✓	
93	Blue Nawab	*Charaxes schreiber tisamenus* (Fruhstorfer, 1914)	I	✓	

Sl. No.	Common Name	Scientific name	WPA	Distribution	
				AI	NI
94	Andaman Viscount	*Tanaecia cibaritis* Hewitson, 1874		✓	
95	Scarce Blue Tiger	*Tirumala gautama gautamoides* (Doherty, 1886)			✓
96	Oriental Blue Tiger	*Tirumala limniace exoticus* (Gmelin, 1790)		✓	✓
97	Dark Blue Tiger	*Tirumala septentrionis septentrionis* (Butler, 1874)		✓	✓
98	Painted Lady	*Vanessa cardui* (Linnaeus, 1758)		✓	
99	Andaman Cruiser	*Vindula erota pallida* Staudinger, 1885		✓	
100	Lurcher	*Yoma sabina vasuki* Doherty, 1886: 10A		✓	
Papilionidae					
101	Andaman Tailed Jay	*Graphium agamemnon andamana* (Lathy, 1907)		✓	
102	Car Nicobar Tailed Jay	*Graphium agamemnon decoratus* (Rothschild, 1895)			✓
103	South Nicobar Tailed Jay	*Graphium agamemnon pulo* (Evans, 1932)			✓
104	Andaman Sword Tail	*Graphium epaminondas* (Oberthur, 1789)		✓	
105	Andaman Great Jay	*Graphium eurypylus macronius* (Jordan, 1909)	II	✓	
106	Great Nicobar Clubtail	*Losaria coon sambilanga* (Doherty, 1886)	I		✓
107	Andaman Clubtail	*Losaria rhodifer* (Butler, 1876)		✓	
108	Camota Common Rose	*Pachliopta aristolochiae camorta* (Moore, 1877)			✓
109	Andaman Common Rose	*Pachliopta aristolochiae goniopeltis* (Rothschild, 1938)		✓	
110	Kondul Common Rose	*Pachliopta aristolochiae kondulana* (Evans, 1932)			✓
111	Car Nicobar Common Rose	*Pachliopta aristolochiae sawi* (Evans, 1932)			✓
112	Crimson Rose	*Pachliopta hector* (Linnaeus, 1758)	I	✓	
113	Andaman Common Mime	*Papilio clytia flavolimbatus* Oberthur, 1879		✓	
114	Lime Butterfly	*Papilio demoleus demoleus* Linnaeus, 1758		✓	✓
115	Andaman Mormon	*Papilio mayo* Atkinson, [1874]	II	✓	
116	Great Mormon	*Papilio memnon agenor* Linnaeus, 1758			✓
117	Nicobar Common Mormon	*Papilio polytes nikobarus* C. Felder, 1863			✓
118	Andaman Common Mormon	*Papilio polytes stichioides* Evans, 1912		✓	
119	Andaman Blue Helen	*Papilio prexaspes andamanicus* Rothschild, 1908	II	✓	

Sl. No.	Common Name	Scientific name	WPA	Distribution	
				AI	NI
120	Nicobar Common Birdwing	*Troides helena ferrari* Tytler, 1926			✓
121	Andaman Common Birdwing	*Troides helena heliconoides* (Moore, 1877)		✓	
Pieridae					
122	Lemon Emigrant	*Catopsilia pomona* (Fabricius, 1775)		✓	✓
123	Mottle Emigrant	*Catopsilia pyranthe pyranthe* (Linnaeus, 1758)		✓	✓
124	Andaman Tree Yellow	*Gandaca harina andamana* Moore, [1906]		✓	
125	Nicobar Tree Yellow	*Gandaca harina nicobaric*a Evans, 1932			✓
126	Andaman One-spot Grass Yellow	*Eurema andersoni evansi* Corbet & Pendlebury, 1932		✓	
127	Car Nicobar Three-spot Grass Yellow	*Eurema blanda moorei* (Butler, 1886)			✓
128	South Nicobar Three-spot Grass Yellow	*Eurema blanda grisea* (Evans, 1932)			✓
129	Three-spot Grass yellow	*Eurema blanda roepstorffi* Moore, 1907		✓	
130	Red-line Small Grass Yellow	*Eurema brigitta rubella* (Wallace, 1867)		✓	
131	Common Grass Yellow	*Eurema hecabe hecabe* (Linnaeus, 1758)		✓	✓
132	Indian Spotless Grass Yellow	*Eurema laeta laeta* (Boisduval, 1836)		✓	✓
133	Oriental Psyche	*Leptosia nina nina* (Fabricius, 1793)		✓	
134	Nicobar Psyche	*Leptosia nina nicobarica* (Doherty, 1886)			✓
135	Andaman Yellow Orange Tip	*Ixias pyrene andamana* Moore, 1877		✓	
136	Common Albatross	*Appias ippie darada* (C. & R. Felder, [1865])	II	✓	✓
137	South Nicobar Chocolate Albatross	*Appias lyncida galbana* Fruhstorfer, 1910			✓
138	Car Nicobar Chocolate Albatross	*Appias lyncida nicobarica* Moore, [1905]			✓
139	Eastern Striped Albatross	*Appias olferna* Swinhoe, 1890			✓
140	Lesser Albatross	*Appias galathea* (C. & R. Felder, [1865])			✓
141	Nicobar Pointed Albatross	*Saletara liberia chrysaea* Fruhstorfer, 1903	II		✓
142	Andaman Lesser Gull	*Cepora nadina andamana* (Swinhoe, 1889)		✓	
143	Andaman Common Gull	*Cepora nerissa lichenosa* (Moore, 1877)		✓	
144	Indo Chinese Common Gull	*Cepora nerissa dapha* (Moore, 1878)	II		
145	Painted Jezebel	*Delias hyparete metarete* Butler, 1879		✓	
146	Indian Painted Jezebel	*Delias hyparete indica* Wallace, 1867		✓	✓
147	Andaman Dark Wanderer	*Pareronia ceylanica naraka* (Moore, 1877)		✓	

Sl. No.	Common Name	Scientific name	WPA	Distribution	
				AI	NI
148	Indian Wanderer	*Pareronia hippie* (Fabricius, 1787)		✓	
149	Indian Pioneer	*Belenois aurota* (Fabricius, 1793)			✓
150	Andaman Great Orange Tip	*Hebomoia roepstorfii* Wood-Mason, 1880		✓	
151	Great Orange Tip	*Hebomoia glaucippe khatrii* Suzuki, 2004		✓	
Lycaenidae					
152	Common Hedge Blue	*Acytolepis puspa cyanescens* (de Niceville, 1890)			✓
153	Common Hedge Blue	*Acytolepis puspa gisca* (Fruhstorfer, 1910)		✓	
154	Common Hedge Blue	*Acytolepis puspa prominens* (de Niceville, 1890)			✓
155	Purple Leaf-blue	*Amblypodia anita andamanica* (Riley, 1922)		✓	
156	Ciliated Blue	*Anthene emolus andamanicus* (Fruhstorfer, 1916)		✓	
157	Pointed Ciliate Blue	*Anthene lycaenina miya* (Fruhstorfer, 1916)	II	✓	
158	Pallid Oak-blue	*Arhopala alesia wimberleyi* (de Niceville, 1887)	II	✓	
159	Broad Banded Oak-blue	*Arhopala asinarus tounguva* (Grose-Smith, 1887)		✓	
160	Plain Tailless Oak-blue	*Arhopala asopia* (Hewitson, 1869)	I	✓	
161	Andaman Centaurus Blue	*Arhopala centaurus coruscans* Wood-Mason & de Niceville, 1880		✓	
162	Spotless Oak-blue	*Arhopala fulla andamanica* (Wood-Mason & de Niceville, 1881)		✓	
163	Rosy Oak-blue	*Arhopala selta constanceae* de Niceville, 1894	I	✓	
164	Andaman Tailless Oak-blue	*Arhopala zeta* (Moore, 1877)	I	✓	
165	Green Flash	*Artipe eryx* (Linnaeus, 1771)		✓	
166	Nicobar Plane	*Bindahara phocides areca* (C. Felder, 1862)	II		✓
167	Andaman Plane	*Bindahara phocides phocides* (Fabricius, 1793)	II	✓	
168	Elbowed Pierrot	*Caleta elna noliteia* (Fruhstorfer, 1918)		✓	
169	Nicobar Straight Pierrot	*Caleta roxus manluena* (C. Felder, 1862)	II		✓
170	Indo-chinese Straight Pierrot	*Caleta roxus roxana* (de Niceville, 1897)		✓	
171	Andaman Common Pierrot	*Castalius rosimon alarbus* Fruhstorfer, 1922	I	✓	✓
172	Common Pierrot	*Castalius rosimon rosimon* (Fabricius, 1775)			✓
173	Andaman Silver Forget-me-not	*Catochrysops panormus andamanica* Tite, 1959		✓	✓

Sl. No.	Common Name	Scientific name	WPA	Distribution	
				AI	NI
174	Forget-me-not	*Catochrysops strabo strabo* (Fabricius, 1793)		✓	✓
175	Felder's Lineblue	*Catopyrops ancyra aberrans* (Elwes, [1893])	II		✓
176	Orchid Tit	*Chliaria othona* (Hewitson, 1865)		✓	
177	Central Nicobar Sunbeam	*Curetis saronis nicobarica* Swinhoe, 1890			✓
178	Car Nicobar Sunbeam	*Curetis saronis obscura* Evans, 1932			✓
179	Andaman Sunbeam	*Curetis saronis saronis* Moore, 1877		✓	
180	Kondula Saronis Sunbeam	*Curetis saronis kondula* Evans, 1954			✓
181	Cornelian	*Deudorix epijarbas amatius* Fruhstorfer, 1912	I	✓	✓
182	Nicobar Banded Blue Pierrot	*Discolampa ethion airavati* (Doherty, 1886)			✓
183	Banded Blue Pierrot	*Discolampa ethion ethion* (Westwood, 1851)		✓	
184	Gram Blue	*Euchrysops cnejus* (Fabricius, 1798)	II	✓	✓
185	Indian Cupid	*Everes lacturnus pila* Evans, [1925]			✓
186	Green Sappire	*Heliophorus epicles latilimbata* Fruhstorfer, 1908		✓	
187	Andaman Voilet Onyx	*Horaga albimacula* (Wood-Mason & de Niceville, 1881)	I	✓	
188	Common Onyx	*Horaga onyx rana* de Niceville, 1889	II	✓	
189	Andaman Common Tit	*Hypolycaena erylus andamana* Moore, 1877		✓	
190	Nicobar Brown Tit	*Hypolycaena thecloides nicobarica* Evans, 1925	II		✓
191	Andaman pointed Lineblue	*Ionolyce helicon brunnea* (Evans, 1932)	II	✓	
192	Nicobar Pointed Lineblue	*Ionolyce helicon kondulana* (Evans, 1932)	II		✓
193	SilverStreak Blue	*Iraota timoleon timoleon* (Stoll, [1790])		✓	
194	Andaman Metallic Cerulean	*Jamides alecto fusca* Evans, 1932		✓	
195	Nicobar Metallic Cerulean	*Jamides alecto kondulana* (C. Felder, 1862)	II		✓
196	Dark Cerulean	*Jamides bochus bochus* (Stoll, [1882])		✓	
197	Nicobar Dark Cerulean	*Jamides bochus nicobaricus* de Niceville, 1890			✓
198	Andaman Common Cerulean	*Jamides celeno blairana* Evans, 1925		✓	
199	Nicobar Common Cerulean	*Jamides celeno kinkura* (C. Felder, 1862)			✓
200	South Nicobar Common Cerulean	*Jamides celeno nicevillei* Evans, 1925			✓
201	Glistening Cerulean	*Jamides elpis croculana* (Fruhstorfer, 1915)			✓
202	Ferrar's Cerulean	*Jamides ferrari ferrari* Evans, 1932	I		✓

Sl. No.	Common Name	Scientific name	WPA	Distribution	
				AI	NI
203	Frosted Cerulean	*Jamides kankena* (C. Felder, 1862)	II		✓
204	Peablue	*Lampides boeticus* (Linnaeus, 1767)	II	✓	✓
205	Nicobar Yamfly	*Loxura atymnus nicobarica* Evans, 1932			✓
206	Andaman Yamfly	*Loxura atymnus prabha* (Moore, 1877)		✓	
207	Plain Cupids	*Luthrodes pandava* (Horsfield, [1829])		✓	✓
208	Andaman Malayan	*Megisba malaya presbyter* Fruhstorfer, 1918	II		✓
209	Variable Malayan	*Megisba malaya sikkima* Moore, 1884		✓	
210	Nicobar Rounded Sixlineblue	*Nacaduba berenice nicobaricus* (Wood-Mason & de Niceville, 1881)			✓
211	Rounded Sixlineblue	*Nacaduba berenice plumbeomicans* (Wood-Mason & de Niceville, 1881)		✓	
212	Opaque Sixlineblue	*Nacaduba beroe gythion* Fruhstorfer, 1916		✓	
213	Plane Fourlineblue	*Nacaduba hermus vicania* Corbet, 1938	II		✓
214	Transparent Sixlineblue	*Nacaduba kurava euplea* Fruhstorfer, 1916		✓	
215	South Nicobar Transparent Sixlineblue	*Nacaduba kurava sambalanga* Tite, 1963			✓
216	Andaman Large Fourlineblue	*Nacaduba pactolus andamanica* Fruhstorfer, 1916	II	✓	
217	Nicobar Large Fourlineblue	*Nacaduba pactolus macropthalma* (C. Felder, 1862)	II		✓
218	Small Fourlineblue	*Nacaduba pavana singapura* Corbet, 1938		✓	
219	Thai Small Four-Lineblue	*Nacaduba pavana vajuva* Fruhstorfer, 1916			
220	Jewel Fourlineblue	*Nacaduba sanaya elioti* Corbet, 1938			✓
221	Andaman Voilet Fourlineblue	*Nacaduba subperusia lysa* Fruhstorfer, 1916		✓	
222	Nicobar Voilet Fourllineblue	*Nacaduba subperusia nadia* Eliot, 1955			✓
223	Andaman Quaker	*Neopithecops zalmora andamanus* Eliot & Kawazoe, 1983		✓	
224	Forest Quaker	*Pithecops corvus correctus* Cowan, 1966			
225	Dingy Lineblue	*Petrelaea dana* (de Niceville, [1884]		✓	
226	White Royal	*Pratapa deva lila* Moore, 1884	II	✓	
227	Barred Lineblue	*Prosotas aluta coelestis* (Wood-Mason & de Niceville, [1887])	II	✓	
228	Tailless Lineblue	*Prosotas dubiosa indica* (Evans, [1925])		✓	
229	Common Lineblue	*Prosotas nora dilata* (Evans, 1932)			✓
230	Andaman Common Lineblue	*Prosotas nora fulva* (Evans, 1925)	II	✓	

Sl. No.	Common Name	Scientific name	WPA	Distribution	
				AI	NI
231	Banded Royal	*Eliotiana jalindra tarpina* Hewitson, 1878	II	✓	
232	Malayan RedEye	*Rapala damona* Swinhoe, 1890		✓	
233	Scralet Flash	*Rapala dieneces intermedia* (Staudinger, 1888)		✓	
234	State Flash	*Rapala manea schistacea* (Moore, 1879)		✓	
235	Suffused Flash	*Rapala suffusa suffusa* (Moore, 1878)			
236	Indigo Flash	*Rapala varuna orseis* (Hewitson, [1863])	II	✓	
237	Nicobar IndigoFlash	*Rapala varuna rogersi* Swinhoe, 1911	II		✓
238	Chocolate Royal	*Remelana jangala andamanica* (Wood-Mason & de Niceville, 1881)	II	✓	
239	Common Apefly	*Spalgis epius epius* (Westwood, [1851])			✓
240	Nicobar Apefly	*Spalgis epius nubilus* Moore, [1884]		✓	✓
241	Long Banded Sliverline	*Spindasis lohita zoilus* (Moore, 1877)	II		✓
242	Burmese Acacia blue	*Surendra vivarna latimargo* Moore, 1879		✓	
243	Pecock Royal	*Tajuria cippus cippus* (Fabricius, 1798)	II	✓	
244	Scarce Guava Blue	*Virachola similis maseas* Fruhstorfer, 1912	I	✓	
245	Fluffy Tit	*Zeltus amasa* (Hewitson, 1865)		✓	✓
246	Dark Grassblue	*Zizeeria karsandra* (Moore, 1865)		✓	✓
247	Lesser Grassblue	*Zizina otis otis* Fabricius, 1787		✓	✓
248	Lesser Grassblue	*Zizina otis sangra* (Moore, [1866])		✓	✓
249	Tiny Grassblue	*Zizula hylax* (Fabricius, 1775)		✓	
Hesperiidae					
250	Forest Hopper	*Astictopterus jama olivascens* Moore, 1878		✓	
251	Brown Awl	*Badamia exclamationis* (Fabricius, 1775)		✓	✓
252	Andaman Paint Brush Swift	*Baoris farri scopulifera* Moore, [1884]	IV	✓	
253	Orange Tailed Awl	*Bibasis sena sena* (Moore, [1866])		✓	
254	Common Rice Swift	*Borbo cinnara* (Wallace, 1866)		✓	✓
255	Small Green Awlet	*Burara amara* (Moore, [1866])		✓	
256	Orange Striped Awlet	*Burara harisa andamana* Chiba & Tsukiyama, 2009		✓	
257	Andaman Orange Awlet	*Burara jaina astigmata* (Evans, 1932)		✓	
258	Andaman colon swift	*Caltoris cahira cahira* (Moore, 1877):		✓	✓
259	Andaman Yellow-banded Flat	*Celaenorrhinus andamanicus andamanicus* Wood Mason & de Niceville, 1881		✓	

Sl. No.	Common Name	Scientific name	WPA	Distribution	
				AI	NI
260	Dark yellow banded Flat	*Celaenorrhinus aurivittatus* (Moore, 1879)		✓	
261	Common Spotted Flat	*Celaenorrhinus leucocera* (Kollar, [1844])		✓	✓
262	Nicobar Plain Palm Dart	*Cephrenes acalle nicobarica* Evans, 1932		✓	✓
263	Plain Palm Dart	*Cephrenes acalle oceanica* (Mabille, 1904)		✓	✓
264	Wax Dar	*Cupitha purreea* (Moore, 1877)		✓	
265	Small Palm-redeye	*Erionota acroleuca* (Wood-Mason & De Niceville, 1881)			
266	Palm Red Eye	*Erionota thrax thrax* (Linnaeus, 1767)		✓	✓
267	Banded Redeye	*Gangara lebadea andamanica* (Wood-Mason & de Niceville, 1881)		✓	
268	Giant Redeye	*Gangara thyrsis thyrsis* (Fabricius, 1775)		✓	✓
269	Andaman Common Yellow-breasted Flat	*Gerosis bhagava andamanica* Wood Mason & de Niceville, 1881		✓	✓
270	Moore's Ace	*Halpe porus* (Mabille, [1877])		✓	
271	Common Awl	*Hasora badra badra* (Moore, [1858])		✓	✓
272	Common Banded Awl	*Hasora chromus chromus* (Cramer, [1780])		✓	✓
273	Cachar Large Banded Awl	*Hasora khoda coulteri* Wood-Mason & de Niceville, [1887]		✓	
274	Voilet Awl	*Hasora leucospila* (Mabille, 1891)		✓	✓
275	Green Awl	*Hasora salanga* (Plötz, 1885)			✓
276	Andaman White banded Awl	*Hasora taminatus andama* Evans, 1949		✓	
277	Nicobar White Banded Awl	*Hasora taminatus milona* Evans, 1932			✓
278	Andaman Plain Banded Awl	*Hasora vitta manda* Evans, 1949	IV	✓	
279	Tree Flitter	*Hyarotis adrastus praba* (Moore, [1866])	IV	✓	
280	Common Redeye	*Matapa aria* (Moore, [1866])		✓	
281	Dark-banded Redeye	*Matapa cresta* Evans, 1949		✓	
282	Grey-banded Redeye	*Matapa druna* (Moore, [1866])		✓	
283	Restricted Demon	*Notocrypta curvifascia curvifascia* (C. & R. Felder, 1862)		✓	✓
284	Andaman Common Banded Demon	*Notocrypta paralysos paralysos* (Wood-Mason & de Niceville, 1881)		✓	✓
285	Andaman Common Dartlet	*Oriens gola gola* (Moore, 1877)		✓	
286	Common Dartlet	*Oriens gola pseudolus* (Mabille, 1883)			✓
287	Malay Dartlet	*Oriens paragola* de Niceville, 1895			✓

Sl. No.	Common Name	Scientific name	WPA	Distribution	
				AI	NI
288	Obscure Banded Swift	*Pelopidas agna agna* (Moore, [1866])		✓	
289	Conjoined Swift	*Pelopidas conjuncta conjuncta* (Herrich-Schaffer, 1869)		✓	✓
290	Small Banded Swift	*Pelopidas mathias mathias* (Fabricius, 1798)		✓	✓
291	Contiguous Swift	*Polytremis lubricans lubricans* (Herrich-Schaeffer, 1869)	IV	✓	
292	Andaman Dartlet	*Potanthus confucius nina* (Evans, 1932)		✓	
293	Andaman Large Dartlet	*Potanthus hetaerus serina* (Ploetz, 1883)		✓	
294	Andaman Broad Bident Dart	*Potanthus trachala ottalina* (Evans, 1932)		✓	
295	Common Small Flat	*Sarangesa dasahara sandra* Evans, 1949		✓	
296	Andaman Small Palm Bob	*Suastus minutus aditus* Moore, 1884		✓	
297	Andaman Large Snow Flat	*Tagiades gana alica* Moore, 1877		✓	
298	Car Nicobar Suffused Snow Flat	*Tagiades japetus carnica* Evans, 1934			✓
299	Little Nicobar Suffused Snow Flat	*Tagiades japetus helferi* C. & R. Felder, 1862			✓
300	Central Nicobar Suffused Snow Flat	*Tagiades japetus nankowra* Evans, 1934			✓
301	Andaman Suffused Snow Flat	*Tagiades japetus ravina* Fruhstorfer, 1910			✓
302	Andaman Water Snow Flat	*Tagiades litigiosa andamanica* Evans, 1932		✓	
303	Andaman Plain Palm Dart	*Telicota colon kala* (Evans, 1934)		✓	
304	Andaman Purple-spotted Flitter	*Zographetus ogygia andamana* Evans, 1926		✓	
Riodinidae					
305	Andaman Plum Judy	*Abisara bifasciata bifasciata* Moore, 1877		✓	

Sources: Wood-Mason and de Nicéville 1880, 1881a, b, 1882: Evans 1932; Ferrar 1948; Khatri 1993b, Vane-Wright 1993; Veenakumari and Prashanth Mohanraj 2011

Plate 1: Nymphalidae of Andaman and Nicobar Islands

Doleschallia bisaltide andamanensis Fruhstorfer, 1899

Parthenos sylvia roepstorfii Moore, 1897

Tirumala limniace exoticus (Gmelin, 1790)

Cupha erymanthis andamanica Moore, (1900)

Hypolimnus bolina jacintha (Drury, 1773)

Vindula erota pallida Staudinger, 1885

Plate 2: Papilionidae of Andaman and Nicobar Islands

Troides helena heliconoides (Moore, 1877)

Graphium epaminondas (Oberthur, 1789)

Pachliopta aristolochiae goniopeltis (Rothschild, 1938)

Papilio polytes stichioides (Evans, 1912)

Losaria rhodifer (Butler, 1876)

Papilio memnon agenor (Linnaeus, 1758)

Plate 3: Pieridae of Andaman and Nicobar Islands

Appias lyncida galbana (Fruhstorfer, 1910)

Appias albina darada (C. & R. Felder, 1865)

Leptosia nina nicobarica (Doherty, 1886)

Eurema hecabe hecabe (Linnaeus, 1758)

Cepora nerissa lichenosa (Moore, 1877)

Ixias pyrene andamana (Moore, 1877)

Plate 4: Lycaenidae of Andaman and Nicobar Islands

Deudorix epijarbas amatius (Fruhstorfer, 1912)

Nacaduba pactolus andamanica (Fruhstorfer, 1916)

Hypolycaena erylus andamana (Moore, 1877)

Bindahara phocides areca (C. Felder, 1862)

Rapala manea schistacea (Moore, 1879)

Spindasis lohita zoilus (Moore, 1877)

Plate 3: Pieridae of Andaman and Nicobar Islands

Hyarotis adrastus praba (Moore, 1866)

Halpe porus (Mabille, 1877)

Gerosis bhagava andamanica (Wood Mason & de Niceville, 1881)

Burara harisa harisa (Moore, 1866)

Hasora taminatus andama (Evans, 1949)

Potanthus confucius nina (Evans, 1932)

References

Anonymous. 2014. The Wild Life (Protection) Act, 1972. Universal Law Publishing Co. Pvt., Ltd. New Delhi

Arora, G. S. & Nandi, D. N. 1980. On the butterfly fauna of Andaman and Nicobar Islands (India) I. Papilionidae. *Records of Zoological Survey of India* 77: 141–151.

Arora, G. S. & Nandi, D. N. 1982. On the butterfly fauna of Andaman and Nicobar Islands India II. Pieridae. *Ibid* 80: 1–15

Atkinson, W.S. 1874. Descriptions of two new species of butterflies from the Andaman Islands. *Proceedings of the Zoological Society of London*, 1873(3), 736.

Beccaloni, G.W. & Gaston, K.J. 1995. Predicting the species richness of Neotropical forest butterflies: Ithomiinae Lepidoptera: Nymphalidae) as indicators. *Biological Conservation* 71; 77-86.

Bonebrake, T.C., Ponisio, C.L Boggs, C. L & Ehrlich, P. R. 2010. More than just indicator: a review of tropical butterfly ecology and conservation. *Biological Conservation* 143:1831-1841.

Chandra, K. & Khatri, T. C. 1995. Butterflies of great Nicobar Islands. *Indian Journal of Forestry* 18 (4): 276–273

Chandra, K. & Rajan, P. T. 1996. Butterflies of North, Middle and South Button Islands National Parks, Andaman. *Insect Environment* 2(3), 110–111.

Chaturvedi, N. 1982. Butterflies of Andaman Islands with some new records. *Journal Bombay Nat History Society* 79 (3): 702–704.

Chaturvedi, N. & Hussain, S. A. 1991. Some butterflies of Narcondam Island (Andaman). *Journal Bombay Natural History Society* 88(3): 463

Davidar, P., Palavai, V., Yoganand, K., Ganesh, T. & Devy, M.S. 2010. Distributional patterns of some faunal groups in the Andaman Islands: Conservation implications. In Recent Trends in Biodiversity of Andaman and Nicobar Islands, Vedam Books International, N. Delhi. 542 p

DeVries Phil. J., Vidar Grotan, Russell Lande, Steinar Engen & Bernt-Erik Saether. 2012. Seasonal cycles of species diversity and similarity in a tropical butterfly community. *Journal of Animal Ecology* 2012, 81, 714–723.

Devy, M. S., Ganesh, T. & Davidar, P, 1994. A preliminary survey of the butterflies on some Islands in the Andamans. *Journal of Andaman Science Association,* 10, 50–56.

Devy, M. S., Ganesh, T. & Davidar, P. 1998. Patterns of butterfly distribution in the Andaman Islands: implications for conservation. *Acta Oecologia* 19(6):527–534

Evans, W. H. 1932. The identification of Indian butterflies. *Bombay Natural History Society, Bombay*, p 454.

Ferrar, M. L., 1948. Butterflies of Andaman and Nicobar Islands. *Journal of the Bombay Natural History Society* 47(3): 470–491.

FSI (Forest Survey of India), 2019. India State of Forest Report. Forest Survey of India, Dehra Dun.

Xue Guoxi & Philip Yik-Fui Lo, 2015. A taxonomic note on *Erionota acroleuca* (Wood-Mason & de Nicéville, 1881) stat. rest. (Lepidoptera: Hesperiidae). *Zoo-taxa* 3926(3):445-447.

Hewitson, W. C. 1874. List of 41 butterflies collected by Capt. Wimberley in the Andaman Islands. *Annals and Magazine of Natural History*, 14(4), 356–358.

Hills, J.C, Hamer, K.C, Lace, L.A & Banham, W.M.T. 1995. Effects of selective logging on tropical butterflies on Buru, Indonesia. *Journal of Applied Ecology*, 32: 454-460.

Kehimkar, I. 2016. Butterflies of India. *Bombay Natural History Society, Mumbai*, p 505.

Khatri, T. C & Singh, R. K. 1987. A New Record of the Genus *Delias* (Rhopalocaea: Lepidoptera) from Andaman and Nicobar Islands. *Journal of Andaman Science Association* 3(1): 55.

Khatri, T. C. 1989. A revised list of butterflies from Bay Islands. *Journal of Andaman Science Association* 5:57–61.

Khatri, T. C. 1991. On some Nymphalidae (Rhopalocera: Lepidoptera) from the Andaman and Nicobar Islands. *Islands on Mar* 3: 82–94

Khatri, T. C. 1992. On some Lycaenids (Rhopalcocera: Lepidoptera) from Andaman and Nicobar Islands. *Islands on Mar* 6: 8–16

Khatri, T. C. 1993. Butterflies of the Andaman and Nicobar Islands: conservation concerns. *The Journal of research on the Lepidoptera* 32:170–184

Khatri, T. C. & Mitra, B. 1989a. On some Danaidae (Lepidoptera: Rhopalocera) from the Andaman and Nicobar Islands. *Hexapoda* 1:109–116

Khatri, T. C. & Mitra, B. 1989b. Some Pieridae (Lepidoptera: Rhopalocera) from Andaman and Nicobar Islands. *Hexapoda* 1:127–137.

Khatri, T. C. & Singh, R. K. 1988. Some Papilionidae (Lepidoptera: Rhopalocera) from Andaman and Nicobar Islands. *Journal of Andaman Science Association* 4(1):39–46.

Kocher, S. D & Williams, E. H. 2000. The diversity and abundance of North American butterflies vary with habitat disturbance and geography. *Journal of Biogeography* 27:785–794

Kunte, K. 1997. Seasonal patterns in butterfly abundance and species diversity in four tropical habitats in northern Western Ghats. *Journal of Biological Sciences* 22(5):593–603.

Kunte, K. 1999. Determinant of butterfly species diversity: Plant diversity, foliage height diversity and resource richness across vegetation types. MS thesis. Wildlife Institute of India, Dehra Dun.

Kunte, K., S. Sondhi, & P. Roy (Chief Editors), 2020. *Butterflies of India, v. 3.10*. Indian Foundation for Butterflies.

Mohanraj, P. & Veenakumari, K. 1996. Host plants, phenologies and status of swallowtails (Papilionidae: Lepidoptera) in the Andaman and Nicobar Islands, Bay of Bengal, Indian Ocean. *Biological Conservation* 78:215–221.

Mohanraj, P. & Veenakumari, K. 2011. Butterflies of the Andaman and Nicobar islands: History of collection and checklist. *Zoo-taxa* 3050: 1–36.

Moore, F. 1877. The lepidopterous fauna of the Andaman and Nicobar islands. *Proceedings of the Zoological Society of London, 1877*, 580–632. pls. 57–60.

Murphy, D. Dennis, Kathy, E. Freas & Stuart, B. Weiss. 1990. An Environment metapopulation Approach to Population Viability Analysis for a Threatened Invertebrate. *Conservation Biology* Volume 4, No. 1, March 1990

Pollard, E. 1977. A method for assessing changes in the abundance of butterflies. *Biological Conservation* 12:115–134

Pollard, E. & Yates, T. J. 1993. Monitoring butterflies for ecology and conservation. Chapman and Hall, London, p 292

Schulze, C. H. & Fiedler, k. 1998. Habitat preference and flight activity of Morphinae butterflies in a Bornean rainforest, with a note on sound production by adult Zeuxidia (Lepidoptera: Nymphalidae). *Malayan Nature Journal* 52: 163-176.

Schulze, C.H., Schneeweihs & Fiedler, k. 2010. The potential of land use system for maintain tropical forest butterfly diversity, 99. 74-96. In: Tscharntke T, Leuschner C, Veldkamp E, Faust H, Guhardja E, and Bidin A. (eds), Tropical rainforest and agro forests under global change- Ecological and socio economic valuation. *Springer,* Berlin

Simhachalam, P., Gautam, R. K., Ajanta Birah, Baskaran, V. & Dam Roy, S. 2017 Butterfly diversity and distribution in Bloomsdale research farm of ICAR-CIARI, Port Blair, South Andaman Indian. *Journal of Agriculture Research*, 51 (1) 2017: 32-37

Sivaperuman, C. & Venkataraman, K. 2012. Diversity of Butterflies in Ritchie's Archipelago, Andaman and Nicobar Islands. pp. 159-176. In: *Ecology of faunal communities on the Andaman and Nicobar Islands.* (Eds.) K. Venkataraman, C. Raghunathan, and C. Sivaperuman. Springer-Verlag Berlin Heidelberg.

Sivaperuman, C. & Venkataraman, K. 2016. Butterfly Communities of Ritchie's Archipelago in Andaman and Nicobar Islands, India: Implications for Conservation of Arthropods and Their Habitats. A.K. Chakravarthy, S. Sridhara (eds.), Economic and Ecological Significance of Arthropods in Diversified Ecosystems, Sivaperuman, C., Patel, M. C, Dinesh, J. & Gokulakrishnan, G. 2014. Diversity and distribution of Butterflies in North Andaman. *Annals of Forestry* 22(2): 223-243.

Sivaperuman, C., Shah, S. K. & Raghunathan, C., 2010. Diversity of butterflies in Great Nicobar Biosphere Reserve (GNBR), A and N Islands. In: Proceedings of 3rd Asian Lepidoptera conservation symposium and training programme, Zoo Outreach Organisation Coimbatore, Tamil Nadu, India pp. 21.

Sivaperuman, C., Shah, S. K., Raghunathan, C. & Ramakrishna, 2011.Structure and species composition of butterflies in Great Nicobar Biosphere Reserve, Andaman and Nicobar Islands. In: Tyagi BK, Veer V (eds) Entomology: ecology and biodiversity. Scientific Publisher, Jodhpur, pp. 168–179.

Sparrow, H. R., Sisk, T. D., Ehrlich, P. R & Murphy, D. D. 1994. Techniques and guidelines for monitoring neo tropical butterflies. *Conservation Biology* 8: 800-809.

Toussaint Emmanuel F.A., Jerome Moriniere, Chris, J. Muller, Krushnamegh Kunte, Bernard Turlin, Axel Hausmann & Michael Balke. 2015. Comparative molecular species delimitation in the charismatic Nawab butterflies (Nymphalidae, Charaxinae, Polyura) *Molecular Phylogenetic and Evolution 91* (2015) 194–209.

Vane-Wright, R. I. 1993. Milkweed butterflies (Lepidoptera: Danainae) and conservation priorities in the Andaman and Nicobar Islands, India. *Butterflies* 4:21–36

Varshney, R. K. & Smetacekz P (eds.) 2015. A Synoptic Catalogue of the Butterflies of India. Butterfly Research Center, Bhimtal and Indinov Publishing, New Delhi, ii 261pp., 8pl.

Veenakumari, K. & Prashanth Mohanraj, 1991. *Erionota thrax thrax* L. (Lepidoptera: Hesperiidae), a new record to Andaman Islands. *Journal of Andaman Science Association,* 7(2), 91–92.

Veenakumari, K. & Mohanraj, P. 1996. Why Ferrar failed to find second specimen of *Polyura schreiber tisamenus* Fruhstorfer (Lepidoptera: Nymphalidae) in the Andaman Islands, Bay of Bengal, Indian Ocean. *The Entomologist* 115(3): 159-160.

Veenakumari, K., Mohanraj. P. & Sreekumar, P. V. 1997. Host plant utilization by butterfly larvae in the Andaman and Nicobar Islands (Indian Ocean). *Journal of Insect Conservation* 1:235–246

Wei Chia-Hsuan, David J. Lohman, Djunijanti Peggie, Shen-Horn Yen. 2017. An illustrated checklist of the genus *Elymnias* Hübner, 1818 (Nymphalidae, Satyrinae). *ZooKeys* 676: 47–152 (2017)

Wood, B. & Gillman, M. P. 1998. The Effects of disturbance on forest butterflies using two methods of sampling in Trinidad. *Biodiversity and conservation*. 597-616

Wood-Mason J, de Niceville L. 1881b. Second list of Rhopalocerous Lepidoptera from Port Blair. Andaman Islands. *Journal of Asiatic Society of Bengal* 50(4):243–262

Wood-Mason J, de Niceville L. 1882. Second list of Rhopalocerous Lepidoptera from Port Blair. Andaman Islands. *Journal of Asiatic Society of Bengal* 11:14–20

Wood-Mason. J, de Niceville L. 1880. List of diurnal Lepidoptera from Port Blair. Andaman Islands. *Journal of Asiatic Society of Bengal* 49(2):223–243

Wood-Mason. J, de Niceville L. 1881a. List of diurnal Lepidoptera from Port Blair. Andaman Islands. *Journal of Asiatic Society of Bengal* 49(2):223–243

Received : 6th February 2020 Accepted : 4th May 2020

Birds of Narcondam Island, Andaman and Nicobar Islands with an Updated Checklist

Gokulakrishnan, G., *C. Sivaperuman and Dinesh Meena#

Zoological Survey of India, Andaman and Nicobar Regional Centre, Port Blair - 744 102, Andaman and Nicobar Islands
#Andaman and Nicobar Police, Port Blair, Andaman and Nicobar Islands
**corresponding author: c_sivaperuman1@rediffmail.com*

Abstract

The Andaman and Nicobar archipelago consists of 572 islands, Islets, and rocky outcrops with extending over 800 km. The studies on the avifauna of Narcondam Island carried out by the authors for a period of five months starting from January 2020 to May 2020. Total of 95 species belonging to 31 families and 11 orders were recorded during the period of study. Of these, 11 species are new records to Andaman and Nicobar Islands and thirty species new report to Narcondam Island.

Keywords: Andaman, Avifauna, Checklist Narcondam Island

Introduction

The Andaman and Nicobar archipelago consists of 572 islands, islets and rocky outcrops and extending over 800 km, and known for their rich biodiversity (Saldanha, 1989; Tikedar, 1984; Vijayan *et al*., 2000; Jayaraj and Andrews, 2005). These are truly oceanic islands, never having been connected to the mainland during Pleistocene glaciations (Ripley and Beehler, 1989). These islands were once a part of the Asian mainland but got detached some 100 million years ago during the Upper Mesozoic Period due to geological upheaval. The existing groups of islands constitute the physiographic continuation of the mountainous ranges of Naga and Lushai Hills and Arakan Yoma of Burma through Cape Negrais to the Andaman and Nicobar Islands and southeast of Sumatra. The chains of these islands are in fact the camel backs of the submerged mountain ranges projecting above the sea level running north to south between 6° 45′ and 13° 30′ N latitudes and 90° 20’ and 93° 56′ E longitudes with an extent of 8,249 km^2. The Andaman and Nicobar Islands can be broadly divided into two groups, namely, the Andamans and the Nicobars. The Andaman group has 324 islands, of which 25 are inhabited and the Nicobar group is made up of 28 islands, of which 13 are inhabited (Jayaraj and Andrews, 2005). These two groups are separated by the Ten-degree Channel which is about 150 km wide 400 fathoms deep. Average annual temperature varies from 24º C to 28º C. The elevations range from 0 to 732 m at Saddle Peak in North Andaman and 642 m at Mount Thulier in Great Nicobar Island. The rainfall is slightly higher in Nicobar with an annual average of 3000 to 3500 mm. The Continental Shelf of these islands encompasses an area of 35,000 km^2 with an EEZ of 8149 km^2. The mean annual temperature of the Islands ranges from 24 to 28º C. Precipitation is slightly higher in the Nicobar Island group with an average annual rainfall of 3000 to 3500 mm. Zoo-geographically, Andaman and Nicobar Islands occupy a unique position close to the ‘Indo-Malayan region’, which is considered to be a ‘faunistic centre’ from which other subdivisions of the Indo-west Pacific Region recruited their fauna. The fauna of the archipelago is also distinct from that of the mainland India and exhibit strong bio-geographical affinities towards the Southeast Asian countries.

Andaman and Nicobar Islands constitute a globally important biodiversity hotspot. Due to isolation from the mainland, the endemism is very high in all taxa including avifauna (Rao *et al*., 1980; Das, 1999a, 1999b and Andrews, 2001). This archipelago is one of the Endemic Bird Areas (EBA), nineteen sites were identified as Important Bird Areas (IBA), and thirty species are considered endemic to these islands (Stattersfield *et al.,* 1998). Ornithology in the Andaman and Nicobar Islands has a long history and it was started by many British researchers during the middle of 19th century (Blyth, 1845, 1846a, 1846b, 1863 and 1866; Walden, 1866, 1873; Barbe, 1846; Flower, 1860; Tytler, 1864, 1867; Beavan, 1867; Tytler, 1867; Ball, 1870, 1872, 1873; Hume, 1873a,b, 1874a, 1874b, 1876; Prain, 1892; St. John, 1898; Butler, 1899a, 1899b, 1899c, 1900, Cory, 1902; Richmond, 1902; Wilson, 1904; Osmaston, 1905, 1906a,b,c, 1907, 1908, 1932, 1933, 2001; Wickham, 1910; Fleming, 1911; Whitehead, 1912; Oberholser, 1915, 1917, 1919; Ferrar, 1931; Stapylton, 1933, 1934a,b; Whistler, 1940; Gibson-Hill, 1949; Thothathri, 1962; Abdulali, 1964, 1965, 1967a,b, 1976, 1977, 1978a,b, 1979, 1981a,b; Voous, 1965; Thangam, 1966; Bailey *et al.,* 1968; Abdulali and Grubh, 1970).

More recently, many researchers have contributed to knowledge of the avifauna of Andaman and Nicobar Islands (Das, 1971; Mukherjee and Dasgupta, 1975; Dasgupta, 1976; Whitaker, 1976, 1985, 2000; Frith, 1978; Ali, 1980; Saha and Dasgupta, 1980; Bhaskar, 1981a,b; Altevogt and Davis, 1981; Mees, 1981; Mukherjee, 1981; Ali and Ripley, 1983, 1987; Hussain, 1977, 1984, 1991, 1992; Tikader, 1984; Saldanha, 1988, 1989; Balakrishnan, 1989; Ripley and Beehler, 1989; Steadman, 1991; Kazmierczak, 1991; Santharam, 1991,1996, 1997; Sebastian, 1991; Anon., 1992, 1996, 2004a,b,c, 2008; Sankaran, 1993, 1995a,b,c,d,e, 1997, 1998a,b,c,d,e, 2001, 2005; Sankaran and Vijayan, 1993; Vijayan, 1993,1996, 1999, 2006, 2007; Chandra and Rajan, 1994a,b; Chandra and Kumar, 1994; Prakash *et al*., 1994; Saxena, 1994; Davidar *et al*., 1995, 1996, 2001 and 2007; Prakash, 1995; Robertson, 1995; Wahal, 1995; Davidar, 1996; Davidar *et al.,* 1996; Prashanth and Veenakumari, 1996; Unnithan, 1996; Vijayan, 1996, 2007; Thiollay, 1997; Grimmett *et al.,* 1998; Rasmussen, 1998, 2000, 2005a,b,c; Stattersfield *et al*., 1998; Relton, 1999; Sankaran and Sivakumar, 1999; Gandhi, 2000; Sivakumar, 2000, 2003a,b, 2007; Yoganand and Davidar, 2000; Vijayan *et al*., 2000; Vijayan *et al*., 2000, 2005; Vijayan and Sankaran, 2001; Dasgupta *et al*., 2002; Sivakumar and Sankaran, 2002, 2003, 2005a,b; Ali, 2003, 2007; IIRS, 2003; Kulkarni and Chandi, 2003; Vivek and Vijayan, 2003; Yahya and Zarri, 2002a,b; Islam and Rahmani, 2004; Rasmussen and Anderton, 2005; Ezhilarsi and Vijayan, 2006; Ashraf, 2006; Andrews *et al.,* 2006; Samaraweera, 2006; Pande *et al*., 2007; Pande, 2007; Vijayan and Ezhilarasi, 2007; Sankaran and Manchi, 2008; Mamannan, and Vijayan, 2009; Manchi and Sankaran, 2009; Bhopale, 2010; Sivaperuman *et al*., 2010, 2012; Sundaramoorthy, 2010; Pande *et al*., 2011; Rajan and Pramod, 2011a,b,c, 2013; Manchi, 2013; Raman *et al*., 2013; Gokulakrishnan *et al.,* 2014; Manchi and Kumar, 2014; Rajeshkumar *et al*., 2014; Thompson, 2014; Zaibin *et al*., 2014; Gokulakrishnan *et al.,* 2015; Gokulakrishnan and Sivaperuman, 2016; Praveen *et al*., 2016; Sridharan *et al*., 2017).

Among the 32 Asian hornbill species (Poonswad *et al.,* 2013), the Narcondam island is unique for the occurrence of the Narcondam Hornbill *Rhyticeros narcondami*, which is endemic to Andaman Islands (Ali and Ripley, 1987). The Narcondam Hornbill is considered an endangered species according to the IUCN red list threatened Species (IUCN, 2020). It is listed as a Schedule-I of the Indian Wildlife (Protection) Act, 1972.

Methods

Study area

The study was carried out at Narcondam Island Wildlife Sanctuary (6.8 km^2), situated in the oceanic island of volcanic origin (13°30'N and 94°38'E), Northeast of the main Andaman group of islands in the Bay of Bengal, about 180 km west of the Burmese mainland, a small island rises abruptly from the sea. It is located about 240 km northeast of Port Blair in the South Andaman Islands, and about 125 km east of North Andaman. The nearest island is North Andaman, while Coco Island of Myanmar is about 96 km (Pal *et al.,* 2007; Raman *et al.,* 2013). The Narcondam Hornbill found only on this Island which was declared an Important Bird Area (Islam and Rahmani, 2004). Narcondam Island, rising to 706 M above msl (Pal *et al.,* 2007), is an island with the second highest peak.

Field surveys were conducted for a period of five months starting from January 2020 to May 2020 and observations were carried on a fixed path on average 1km radius at each station by using the line transect method (Gaston, 1973; *Burnham et al.,* 1980). The birds were observed during the peak hours of their activity from 0530hr to 1030hr. Observations were also made during other times of the day as per convenience. Bird species were identified using field guides (Grimmett *et al.,* 1998; Robson, 2011; Rasmussen and Anderton, 2012). The common and scientific names of the birds given in the checklist followed by Rassmusen and Anderton (2005), the Order and Family followed by Bird Life International (2019).

Results and discussion

Avifaunal diversity in Narcondam Island

A total of 95 species belonging to 31 families and 11 orders were recorded during the period of study (Table 1). These include 11 new records to Andaman and Nicobar Islands and thirty species new report to Narcondam Island (Hume, 1873; Prain, 1892; Osmaston, 1905; Abdulali, 1971; Hussain, 1984; Abdulali, 1974; Sankaran & Vijayan, 1993; Pande, *et al.*2007; Raman *et al*., 2013; Rasmussen and Anderton, 2012). According to (IUCN, 2019), two species listed under Near Threatened (Nicobar Pigeon and Alexandrine Parakeet) and one species are categorized as Endangered (Narcondam Hornbill). Of the recorded species, 18 were residents, seven were residents with local movement, nine were passage migrants, 55 were winter migrant and four were summer migrants (Table 1). The feeding guilds composition of birds in the study area showed highest in the insectivore and understory insectivores (21) in each category, followed by Aquatic land-dwelling feeder (15), Aquatic feeder (9), Canopy insectivores (7), Frugivores (6), Carnivorous (5), Aerial feeder (4), Piscivores (2), Aquatic aerial feeder (2), and each Frugivores with insectivore and Nectarivore–insectivore (1) (Table 1).

BirdLife International identified 218 endemic bird areas, of these nineteen are found in Andaman and Nicobar Islands (Birdlife International, 2000) and Narcondam Island is one of the Endemic Bird areas. Besides, the Narcondam Hornbill, ten endemic subspecies were recorded namely, Black Baza, Andaman Emerald Dove, Green-Imperial Pigeon, Alexandrine Parakeet, Asian Koel, Andaman Glossy Swiflet, Edible-nest Swiftlet, Hooded Pitta, Andaman Olive-backed Sunbird and Andaman Hill Myna.

Table 1. List of birds recorded from Narcondam Island

Sl. No.	Common Name	Scientific Name	IUCN Status	Residential Status	Foraging Guild
	Pelecaniformes				
	Ardeidae				
1	Pacific Reef-Egret	*Egretta sacra* (Gmelin, 1766)	LC	R	AF
2	Grey Heron	*Ardea cinerea* Linnaeus, 1758	LC	PM	AF
3	Intermediate Egret	*Ardea intermedia* (Wagler,1829)	LC	PM	AF
4	Eastern Cattle Egret	*Bubulcus coromandus* (Boddaert, 1783)	LC	R/LM	AF
5	Chinese Pond-Heron	*Ardeola bacchus* (Bonaparte, 1855)	LC	WM	AF
6	Javan Pond-heron	*Ardeola speciosa* (Horsfield, 1821)	LC	WM	AF
7	Striated Heron	*Butorides striata* (Linnaeus, 1758)	LC	R/LM	AF
8	Malayan Night-Heron	*Goraschius melanolophus minor* Hachisuka, 1926	LC	R/LM	UI
9	Yellow Bittern	*Ixobrychus sinensis* (Gmelin,1789)	LC	WM	AF
10	Chestnut Bittern	*Ixobrychus cinnamomeus* (Gmelin,1789)	LC	R/LM	AF

Sl. No.	Common Name	Scientific Name	IUCN Status	Residential Status	Foraging Guild
	Accipitriformes				
	Accipitridae				
11	Black Baza[ENS]	*Aviceda leuphotes andamanica* Abdulali, 1817	NE	R/LM	C
12	White-bellied Sea-Eagle	*Haliaeetus leucogaster* (Gmelin,1788)	LC	R	C
13	Japanese Sparrowhawk	*Accipiter gularis* (Temminck & Schlegel, 1845)	LC	WM	C
14	Common Buzzard	*Buteo buteo* (Linnaeus, 1758)	LC	WM	C
15	Grey-faced Buzzard	*Butastur indicus* (Gmelin, 1788)	LC	WM	C
16	Oriental Honey-Buzzard	*Pernis ptilorhynchus* (Temminck, 1821)	LC	PM	C
	Gruiformes				
	Rallidae				
17	White-breasted Waterhen	*Amaurornis phoenicurus insularis* Sharpe, 1894	LC	R	ALDF
18	Eastern Baillon's Crake	*Zapornia pusilla* (Pallas, 1776)	LC	WM	ALDF
19	Slaty-legged Crake	*Rallina eurizonoides* (Lafresnaye, 1845)	LC	R	ALDF
20	Slaty-breasted Rail	*Lewinia striatus obscurior* (Hume, 1874)	LC	R	ALDF
21	Watercock	*Gallicrex cinerea* (Gmelin,1789)	LC	WM	ALDF
22	Ruddy-breasted Crake	*Porzana fusca* (Linnaeus, 1766)	LC	R/LM	ALDF
	Charadriiformes				
23	Lesser Sand Plover	*Charadrius mongolus* Pallas,1776	LC	WM	ALDF
24	Greater Sand Plover	*Charadrius leschenaultii* Lesson,1826	LC	WM	ALDF
25	Northern Lapwing	*Vanellus vanellus* (Linnaeus, 1758)	LC	PM	ALDF
	Scolopacidae				
26	Common Snipe	*Gallinago gallinago* (Linnaeus, 1758)	LC	WM	ALDF
27	Common Redshank	*Tringa totanus* (Linnaeus,1758)	LC	WM	ALDF
28	Common Sandpiper	*Actitis hypoleucos* Linnaeus,1758	LC	WM	ALDF
29	Ruddy Turnstone	*Arenaria interpres* (Linnaeus,1758)	LC	WM	ALDF
30	Sanderling	*Ereunetes albus* (Pallas, 1764)	LC	WM	ALDF
	Glareolidae				
31	Oriental Pratincole	*Glareola maldivarum* J.R. Forster, 1795	LC	WM	ALDF
	Laridae				
32	Black-naped Tern	*Sterna sumatrana* Raffles,1822	LC	R/LM	AAF
33	White-Winged Tern	*Chlidonias leucopterus* (Temminck, 1815)	LC	PM	AAF

Sl. No.	Common Name	Scientific Name	IUCN Status	Residential Status	Foraging Guild
34	**Columbiformes**				
35	**Columbidae**				
36	Emerald Dove[ENS]	*Chalcophaps indica maxima* Hartert, 1931	LC	R	UI
37	Red Collared-Dove	*Streptopelia tranquebarica* (Hermann,1804)	LC	R	UI
38	Nicobar Pigeon	*Caloenas nicobarica* (Linnaeus, 1758)	NT	R	UI
39	Green-Imperial Pigeon[ENS]	*Ducula aenea andamanica* (Abdualali, 1964)	LC	R	F
40	Pied Imperial-Pigeon	*Ducula bicolor* (Scopoli, 1786)	LC	R	F
	Psittaciformes				
	Psittaculidae				
41	Alexandrine Parakeet[ENS]	*Psittacula eupatria magnirostris* (Ball, 1872)	NT	R	F
	Cuculiformes				
	Cuculidae				
42	Large Hawk-Cuckoo	*Hierococcyx sparverioides* (Vigors, 1832)	LC	WM	I
43	Chestnut-winged Crested Cuckoo	*Clamator coromandus* (Linnaeus, 1766)	LC	WM	I
44	Himalayan Cuckoo	*Cuculus saturatus* Blyth, 1843	LC	WM	I
45	Square-tailed Drongo Cuckoo	*Surniculus lugubris* (Horsefield, 1821)	LC	WM	I
46	Asian Koel[ENS]	*Eudynamys scolopacea dolosus* Ripley, 1946	LC	WM	F
	Caprimulgiformes				
	Caprimulgidae				
47	Grey Nightjar	*Caprimulgus jotaka* Temminck & Schlegel, 1844	LC	WM	I
	Apodidae				
48	Andaman Glossy Swiftlet [ENS]	*Collocalia esculenta affinis* Beavan 1867	LC	R	Af
49	Edible-nest Swiftlet[ENS]	*Aerodramus fuciphagus inexpectatus* Hume, 1873	LC	R	Af
	Coraciiformes				
	Alcedinidae				
50	Common Kingfisher	*Alcedo atthis* (Linnaeus, 1758)	LC	WM	P
51	Black-capped Kingfisher	*Halcyon pileata* (Boddaert, 1783)	LC	WM	P

Sl. No.	Common Name	Scientific Name	IUCN Status	Residential Status	Foraging Guild
	Coraciidae				
52	Dollarbird	*Eurystomus orientalis gigas* Stesemann, 1913	LC	R	I
	Bucerotiformes				
	Bucerotidae				
53	Narcondam Hornbill[E]	*Rhyticeros narcondami* (Hume, 1873)	EN	R	F, I
	Passeriformes				
	Pittidae				
54	Hooded Pitta[ENS]	*Pitta sordida abbotti* Richmond, 1903	LC	R	UI
55	Blue-winged Pitta	*Pitta moluccensis* (Muller, 1776)	LC	SM	UI
	Hirundinidae				
56	Barn Swallow	*Hirundo rustica* Linnaeus,1758	LC	WM	Af
57	Red-rumped Swallow	*Cecropis daurica* Linnaeus, 1771	LC	WM	Af
	Motacillidae				
58	Forest Wagtail	*Dendronanthus indicus* (Gmelin,1789)	LC	WM	UI
59	White Wagtail	*Motacilla leucopsis* Gould, 1838	NE	WM	UI
60	EasternYellow Wagtail	*Motacilla tschutschensis* Linnaeus, 1758	LC	WM	UI
61	Grey Wagtail	*Motacilla cinerea* Tunstall, 1771	NE	WM	UI
62	Citrine Wagtail	*Motacilla citreola* Pallas, 1776	LC	WM	UI
63	Red-throated Pipit	*Anthus cervinus* (Pallas, 1811)	NE	WM	UI
64	Paddyfield Pipit	*Anthus rufulus* (Vieillot, 1818)	LC	WM	UI
	Campephagidae				
65	Ashy Minivet	*Pericrocotus divaricatus* (Raffles, 1822)	LC	WM	I
	Laniidae				
66	Philippine Shrike	*Lanius cristatus lucionensis* Linnaeus, 1766	LC	WM	I
	Turdidae				
67	Eyebrowed Thrush	*Turdus obscurus* Gmelin, 1789	LC	WM	UI
68	Orange-headed Thrush	*Zoothera citrina* (Latham, 1790)	LC	PM	UI
69	Scaly Thrush	*Zoothera dauma* (Latham, 1790)	LC	SM	UI
70	Siberian Thrush	*Geokichla sibirica* (Pallas,1776)	LC	WM	UI
	Muscicapidae				
71	Siberian Blue Robin	*Larvivora cyane* (Pallas, 1776)	LC	WM	UI
72	Common Stonechat	*Saxicola stejnegeri* (Parrot, 1908)	LC	WM	I

Sl. No.	Common Name	Scientific Name	IUCN Status	Residential Status	Foraging Guild
	Cisticolidae				
73	Eastern Thick-billed Warbler	*Acrocephalus aedon* (Pallas, 1776)	LC	WM	I
	Sylviidae				
74	Lanceolated Warbler	*Locustella lanceolata* (Temminck, 1840)	LC	WM	I
75	Black-browed Reed-Warbler	*Acrocephalus bistrigiceps* Swinhoe, 1860	LC	WM	I
	Phylloscopidae				
76	Dusky Warbler	*Phylloscopus fuscatus* (Blyth, 1842)	LC	WM	I
77	Yellow-browed Warbler	*Phylloscopus inornatus* (Blyth, 1842)	LC	WM	I
78	Arctic Leaf-Warbler	*Phylloscopus borealis* (Blasius, 1858)	LC	WM	I
79	Greenish Leaf-Warbler	*Phylloscopus trochiloides* (Sundevall, 1837)	LC	WM	I
80	Pale-legged Leaf-Warbler	*Phylloscopus tenellipes* Swinhoe, 1860	LC	WM	I
	Muscicapidae				
81	Asian Brown Flycatcher	*Muscicapa latirostris* (Raffles, 1822)	LC	WM	CI
82	Dark-sided Flycatcher	*Muscicapa sibirica* Gmelin, 1789	LC	PM	CI
83	Taiga Flycatcher	*Ficedula albicilla* (Pallas, 1811)	LC	WM	CI
84	Yellow-rumped Flycatcher	*Ficedula zanthopygia* (Hay, 1845)	LC	WM	CI
85	Blue-throated Flycatcher	*Cyornis rubeculoides* (Vigors, 1831)	LC	SM	CI
86	Ferruginous Flycatcher	*Muscicapa ferruginea* (Hodgson, 1845)	LC	SM	CI
	Monarchidae				
87	Amur Paradise-Flycatcher	*Terpsiphone incei* (Gould, 1852)	LC	WM	CI
	Passeridae				
88	Eurasian Tree Sparrow	*Passer montanus* (Linnaeus, 1758)	LC	PM	UI
	Nectariniidae				
89	Olive backed Sunbird[ENS]	*Cinnyris jugularis andamanicus* (Hume, 1873)	LC	R	N, I
	Emberizidae				
90	Little Bunting	*Emberiza pusilla* Pallas, 1776	LC	PM	UI
91	Black-faced Bunting	*Emberiza spodocephala* Pallas, 1776	LC	PM	UI

Sl. No.	Common Name	Scientific Name	IUCN Status	Residential Status	Foraging Guild
	Sturnidae				
92	Andaman Hill Myna[ENS]	*Gracula religiosa andamanensis* (Beavan, 1867)	LC	R	F
93	Purple-backed Starling	*Agropsar sturninus* (Pallas, 1776)	LC	WM	I
	Oriolidae				
94	Slender-billed Oriole	*Oriolus tenuirostris* Blyth, 1846	LC	WM	F
	Dicruridae				
95	Black Drongo	*Dicrurus macrocercus* Vieillot, 1817	LC	WM	I
96	Ashy Drongo	*Dicrurus leucophaeus salangensis* Reichenow, 1890	LC	WM	I
97	Crow-billed Drongo	*Dicrurus annectens* (Hodgson, 1836)	LC	PM	I

Residential Status: R - Resident; R/LM - Resident with local movements; WM - Winter Migrant; PM - Passage migrant; SM - Summer migrant; Residential status followed by (Ali & Ripley, 1983; Rasmussen & Anderton, 2012; Sivaperuman *et al*. 2018).

IUCN Threatened status of the birds given in the checklist is as per IUCN Red List of Threatened Species (Birdlife International 2019).

Foraging: Aerial feeder (Af), Aquatic feeder (AF), Aquatic land-dwelling feeder (ALDF), Aquatic aerial feeder (AAF), Bark surface feeders (BSF), Canopy insectivores (CI), Carnivorous (C), Frugivores (F), Nectarivore - insectivore (NI), Omnivore (O), Piscivores (P), Insectivore (I), Understorey insectivores (UI) (Raman *et al*., 1998).

E- Endemic; ENS - Endemic Subspecies

New record to the Narcondam Island

1. **Grey Heron:** One single individual sighted on the way to light-house on 20th May 2020.
2. **Javan Pond-heron:** This heron was seen along the coast and also near the police barracks in the Month of May 2020. The bird was actively feeding in the water edge along with Chinese Pond-heron.
3. **Striated Heron:** A few individuals were seen feeding over the coast near the landing point & western side of the coast in May 2020.
4. **Malayan Night-Heron:** on 31st March 2020, one individual was sighted from main water source nallah and another individual from police barrack.
5. **Chestnut Bittern:** This was sighted in February-May 2020; a total of five individuals were seen near the police barrack.
6. **Black Baza:** One individual was seen soaring over the western side forest area in the month of April.
7. **Japanese Sparrowhawk:** This bird was reported during February-April 2020 and only one individual was seen near the police barrack.
8. **Oriental Honey-Buzzard:** One individual was recorded on 23rd May 2020 near the police barrack.
9. **Eastern Baillon's Crake:** A single bird was sighted in February 2020 near the police barrack.
10. **Slaty-breasted Rail:** One single individual was seen on the way to light-house on 7th May 2020.
11. **Ruddy-breasted Crake:** Two individual was recorded in February-April 2020 near the police barrack.
12. **Watercock:** Two individuals were sighted in February-April 2020 near the police barrack.
13. **Sanderling:** One individual was seen at landing point, along the shoreline and it was reported during February-April 2020.
14. **Red Collared-Dove:** The dove species was seen resting in a Police Barrack of on 20th March 2020.
15. **Large Hawk-Cuckoo:** This Cuckoo was sighted in three different locations on 31st March, 2020. This was resting in tree near police barrack, A second bird was sighted on 6th April 2020 near the

main water source nallah and third individual was seen from the western side of the island.

16. **Square-tailed Drongo Cuckoo:** This Cuckoo was sighted at three different locations on 31st March 2020, it was spotted resting in tree near to the police barrack, second time was sighted on 6th April 2020 near the main water source nallah, the third individual was seen to the western side of the island.

17. **Citrine Wagtail:** One individual was seen feeding on rocks along the coast of landing point & western side coastal areas on 27th April 2020.

18. **Ashy Minivet:** Two individuals were seen perched on tree and feeding over the canopy during March-April 2020. Again, this bird was observed for main water source nallah and another individual from police barrack.

19. **Siberian Blue Robin:** This robin male & female sighted sight at three different locations during February to May, 2020, such as near police barrack, main water source nallah and western side of the island.

20. **Common Stonechat:** Male & female sighted on April to May, 2020 and this bird was resting in an herb near to the police barrack.

21. **Lanceolated Warbler:** The bird was sighted on 31st March 31, 2020 and this was resting in a tree near to the police barrack.

22. **Black-browed Reed-Warbler:** One individual was seen feeding over the herb near the landing point.

23. **Daurian Starling:** Daurian Starling were observed on 19th February 2020 from the western side of the island.

24. **Amur Paradise-Flycatcher:** During March-May 2020 observed from the main water source.

25. **Blue-throated Flycatcher:** Two individual was sighted during February-April 2020 near to the main water source nallah.

26. **Little Bunting:** This was seen near the police barracks on 30th March 2020; 18th May, 2020.

27. **Purple-backed Starling:** Two individuals were seen perched on tree and feeding over the canopy on 31st March 2020.

28. **Black Drongo:** This bird was sighted in three different locations on 31st March 2020, and this was resting in a tree near police barrack, on 6th April 2020 near the main water source nallah and third was seen to the western side of the island.

29. **Ashy Drongo:** This was sighted at three different locations on 31st March, 2020, one was resting in tree near police barrack, the second bird was sighted on 6th April 2020 near the main water source nallah and thirds was seen to the western side of in this island.

30. **Crow-billed Drongo:** One single individual was seen on the way to light-house, on 07 May 2020.

New record to Andaman and Nicobar Islands

1. **Common Buzzard:** A flock of five individual were sighted near to the light-house, 700M elevation hill top (13°26.961' N; 94°15.880 E), near barrack (13°27.126'N; 94°16.546' E) during this January to April.

2. **Chestnut-winged Crested Cuckoo:** Chestnut-winged Crested Cuckoo was sighted at three different locations on 31st March 2020 an adult bird was sighted near to the police barrack (13°27.126' N; 94°16.546' E), and observed for about 10 minutes through binoculars for about 5 – 10 mts. The second bird was sighted on 6th April 2020 near the main water source nallah (13°26.5089'N; 94°16.1370' E), the third individual was seen to the western side of the island (13°27.656' N; 94°15.935' E). This bird species breeds in Himalayas (Grimmett *et al.*, 2011) and migrate along the Eastern Ghats in its southward migration with exhausted individuals often being discovered in the vicinity of homes (Krishnan, 1954; Raju, 1979). During October, this was reported from Point Calimere, winter in the Western Ghats (Comber, 1901). According to

the available literature, this species has not been recorded from Andaman and Nicobar Islands (Grimmett *et al.,* 2011; Rasmussen and Anderton, 2012; Praveen *et al*., 2018).

3. **Scaly Thrush:** On 8th April 2020 at 0600 hrs observed feeding grass on the ground near to the police barrack (13°27.126'N; 94°16.546' E). The observed individua was olive brown upper body, whitish under body with heavy blackish scales, two buffy-white bands on underwings and white-tipped outer tail feathers and this was not reported from Andaman and Nicobar Islands (Grimmett *et al.* 2011; Rasmussen and Anderton, 2012; Robson, 2008).

4. **Paddy-field Pipit:** On 11th March 2020 at 0600 hrs, observed resting on grass and open rocky near to the police barrack (13°27.126'N; 94°16.546' E). The breast is streaked and the upperparts have variable amounts of streaking.

5. **Dark-sided Flycatcher:** One individual was seen resting in mango tree branch near to the police barrack (13°27.221'N; 94°16.411'E) on 27 April 2020.

6. **Yellow-rumped Flycatcher:** On 23 March 2020, we have sighted in three different locations and this was feeding caterpillar near to the police barrack (Lat: 13°27.221'N; Long: 94°16.411'E). A second bird was sighted on 16th April 2020 Light House (Lat: 13°27.607' N; Long: 94°15.751 E). Third bird was sighted on 24th April 2020 near the main water source nallah (13°26.5089'N; 94°16.1370' E).

7. **Ferruginous Flycatcher:** On 31st March 2020, bird was spotted and observed from the main water source nallah (13°26.5089'N; 94°16.1370' E). The bird was salty grey cast to head, pale eyeing, rufescent rump, upper tail coverts and tail, rusty rufous fringes on coverts tertials and rusty-buff breast and flanks.

8. **Black-faced Bunting:** On 27th April 2020 one individual of Bunting was sighted near to the police barrack (Lat: 13°27.221'N; Long: 94°16.411'E). The bird was seen actively feeding grass seeds on the ground among other species such as Little Bunting.

9. **Slender-billed Oriole:** Slender-billed Oriole from the water source nallah on 27th March 2020 (13°26.5089'N; 94°16.1370' E). The bird is distinguished from the Black-naped Oriole on the basis of its long, slender, slightly curved bill and narrower nape band (Rasmussen and Anderton, 2012).

10. **Eurasian Tree Sparrow:** A total of 19 species of birds were introduced to the Andaman and Nicobar Islands from mainland India during the first half of the 19th Century (Lever 1987; Sankaran and Vijayan 1993), among them the Eurasian Tree Sparrow was introduced in the year of 1866. According to Rajan and Pramod (2013), there is no further recent reports of this species in Andaman Islands. On 12th February 2020 this bird was sighted near to the police barrack (Lat: 13°27.221'N; Long: 94°16.411'E) and observed regularly about ten days in the same location. The sighting of the Eurasian Tree Sparrow from this island after a gap of 154 years and it is new recent site record to Andaman and Nicobar Islands.

11. **Orange-headed Thrush:** Orange-headed Thrush is a medium-sized bird having 12 subspecies in South-east Asia (Clement *et al*., 2000) of which five subspecies are restricted to south Asia and two are endemic to Andaman and Nicobar Islands, *Zoothera citrina andamanensis* from Andaman, *Zoothera citrina albogularis* from Nicobar (Ali and Ripley, 1983; Rasmussen and Anderton, 2012). *Zoothera citrina gibsonhilli* was seen on 30th March 30, 2020, and this was drinking water at near police barrack. These birds are breeds in the southern Burma to southern Thailand, and winters further south at lower levels in the Thailand Peninsula, on islands in the Gulf of Thailand, Singapore and Malaysia.

Avifaunal studies in Narcondam Island have long history and this island received attention after the discovery of Narcondam Hornbill by Hume (1873). Of the 62 species of hornbills found in the world, Narcondam Hornbill has the smallest global geographic range and found only on Narcondam. Prain (1892) carried out an investigation to explore the fauna and flora in Narcondam and Barren Islands, and reported eighteen species of birds, land snake, water monitor, skink, sea turtle and few invertebrates from this island. Cory (1902) made a short visit to study the Narcondam Hornbill. Osmaston (1905) has reported seventeen species of birds and few other vertebrates such as fruit bats, rats, water monitor lizard, skink and snake. First detailed study on feeding, breeding Narcondam Hornbill and population estimate of Narcondam Hornbill has been carried out by Sankaran (1998) who estimated about 330 to 360 individuals. Recently, Raman *et al*. (2013) made a rapid expedition to Narcondam Island and reported 17 species of fishes, two species of sea cucumber, 13 species of spiders, eight species of butterflies, eight species of reptiles, 28 species of birds and two species of mammals.

Our data increases the understanding of some of the rare and poorly known bird species from the Narcondam Island. This paper provides the updated checklist and information on the new records on the avifauna. The present findings stress the significance of periodical ornithological surveys in Narcondam Island for updating the avifaunal biodiversity not only for new records also but for better management and conservation. This five-month expedition to the Narcondam Island has yielded eleven new records to Andaman and Nicobar Island and three new report to Narcondam Island. The Narcondam Island is one of the remotest islands in the Andaman group, because of isolation and remoteness, they are also more likely to harbor high levels of endemic species. Only few expeditions have been carried out in Narcondam Islands by various group of scientists over the past 150 years and most of the team has stated only few hours and day, except Late Dr. Ravi Sankaran who has stayed about three months to study the breeding ecology of Narcondam Hornbill. The present expedition is the 14th since A. O. Hume's expedition of 1873 that resulted in the discovery of the Narcondam Hornbill. The Narcondam Island has a complex and varied geological history that has resulted in a diverse and highly endemic fauna. It is important to continue and updating the knowledge on the distribution of bird communities in Island ecosystem, which provides the building blocks for ongoing and future research. Contributions like the present reports provide a record of change in the status and distribution of the island avifauna.

Acknowledgments

We thank to the Dr. Kailash Chandra, Director, Zoological Survey of India, Kolkata for providing necessary support. We are grateful to the Department of Environment and Forests, Andaman and Nicobar Administration for giving the permission to conduct faunal survey. We thank to the Mr. D. M. Shukla, Principle Chief Conservator & Chief Wildlife Warden, Department of Environment and Forests, Inspector General Shri. M.V. Pathak, Indian Coast Guard for permission to travel by Indian Coast Guard Ship, Director General of Police Shri. Devendra Pathak, Andaman and Nicobar Police for permission to stay along with police personnel posted at Narcondam Island.

References

Abdulali, H. 1964. The birds of the Andaman and Nicobar Islands. *J. Bombay nat. Hist. Soc.* 63: 140-190.

Abdulali, H. 1965. The birds of Andaman and Nicobar Islands. *J. Bombay Hist. Soc.* 61: 483-571.

Abdulali, H. 1967a. More new races of the birds from the Andaman and Nicobar *J. Bombay nat. Hist. Soc.* 63: 420–422.

Abdulali, H. 1967b. The birds of Nicobar Islands. *J. Bombay nat. Hist. Soc*. 64: 139-190.

Abdulali, H. 1976. The fauna of Narcondam Island. *J. Bombay nat. Hist. Soc.* 71: 496–505.

Abdulali, H. 1977. New name of Andaman Blackheaded Oriole, *Oriolus xanthornus andamanensis* Abdulali. *J. Bombay nat. Hist. Soc.* 73 (2): 395.

Abdulali, H. 1978a. The fauna of Narcondam Island. Part 1. Birds. In: A Bundle of Feathers Proffered to Sálim Ali for his 75th Birthday in 1971. 151–160. Ripley, S. D., II (ed.) Delhi: Oxford University Press.

Abdulali, H. 1978b. The birds of Great and Car Nicobars with some notes on wildlife conservation in the Islands. *J. Bombay nat. Hist. Soc.* 75(3): 744–772.

Abdulali, H. 1981a. The birds of Great and Car Nicobars with some notes on Wildlife conservation in the islands. *J. Bombay nat. Hist.Soc.* 75: 744–772.

Abdulali, H. 1981b. Additional notes on Andaman birds. *J. Bombay nat. Hist. Soc*. 78: 46-49.

Abdulali, H. & Grubh, R.B. 1970. A new race of the Blackcrested Baza, *Aviceda leuphotes* (Dumont), from the Andaman Islands. *J. Bombay nat. Hist. Soc.* 67 (2): 137–138.

Abdulali, H. 1971. Narcondam Island and notes on some birds from the Andaman Islands. *J. Bombay Nat. Hist. Soc.* 68, 385–411.

Ali, S. 1980. The Andamans. An 'Endangered Species'! Hornbill 1980 (1): 3, 8.

Ali, R. 2003. Invasive species in Andamans. *Newsletter for Birdwatchers* 43 (4): 48–49.

Ali, R. 2007. Issues relating to invasives in the Andaman Islands. *J. Bombay nat. Hist. Soc.* 103 (2&3): 349–355.

Ali, S. & Ripley, S.D. 1983. Handbook of the birds of India and Pakistan. Compact edition. New Delhi: Oxford University Press.

Ali, S. & Ripley, S.D. (1987) Compact handbook of the birds of India and Pakistan together with those of Bangladesh, Nepal, Bhutan and Sri Lanka. 2nd ed. Delhi: Oxford University Press.

Altevogt, R. & Davis, T.A. 1981. Nocturnal activity of the Turnstone (*Arenaria interpres*) on South Sentinel (Andaman Islands). *J. Bombay nat. Hist. Soc.* 77 (3): 508–510.

Andrews, H.V. 2001. Threatened herpetofauna of the Andaman and Nicobar Islands. Pp 39-47. In: An over view of the threatened herpetofauna of South Asia, (Eds.) Bambaradeniya CN, Samarasekara VN, IUCN Sri Lanka and Asia Regional Biodiversity Programme, Colombo, Sri Lanka.

Andrews, H.V. Jayaraj, R.S.C, & Mundoli, S. 2006. State of environment 2005, Andaman and Nicobar Islands. Hyderabad, India: Universities Press (India) Pvt. Ltd.

Anon. 1992. Nicobar Megapode. *WPA News* 37 (August): 33.

Anon. 1996. Barn Owl in Andaman & Nicobar Islands. *Pitta* 67 & 68: 2

Anon. 2004a. Avifaunal diversity of the Andaman Islands and their conservation. In: Annual Report 2003–2004. 4–5. Coimbatore: Salim Ali Centre for Ornithology and Natural History.

Anon. 2004b. In-situ & ex-situ conservation of the Ediblenest Swiftlet *Collocalia fuciphaga* in the Andaman & Nicobar Islands. In: Annual Report 2003–2004. 12. Coimbatore: Salim Ali Centre for Ornithology and Natural History.

Anon. 2004c. Status and ecology of the Andaman Crake. In: Annual Report 2003–2004. 5 – 6. Coimbatore: Salim Ali Centre for Ornithology and Natural History.

Anon. 2008. Conservation of the Edible-nest Swiftlet *Collocalia fuciphaga* in the Andaman and Nicobar Islands. Pp. 31. Project Report. Coimbatore, India: Salim Ali Centre for Ornithology & Natural History; Forest Department of Andaman and Nicobar Islands.

Anon. 1989. Handbook on Andamans district. Andaman and Nicobar Administration, State Statistical Bureau, Govt. Press, Port Blair.

Ashraf, M.A. 2006. Island biogeography - the forest birds of the Andaman Islands as a case study. *Tigerpaper* 1 (30–32)

Bailey, R.S., Pocklington, R. and Willis, P.R. 1968. Storm-petrels *Oceanodroma* spp. in the Indian Ocean. *Ibis* 110: 27–34.

Balakrishnan, N.P. 1989. Andaman Islands vegetation and floristics. pp. 55-61. In C. J. Saldanha (Ed). Andaman, Nicobar and Lakshadweep an environment impact assessment. New Delhi: Oxford University Press.

Ball, V. 1870. Notes on birds observed in the neighborhood of Port Blair, Andaman Islands, during month of August 1864. *J. Asiatic Soc. Bengal* 39: 240–243.

Ball, V. 1872. Notes on a collection of birds made in Andaman Islands by Asst. Surgeon, G. E. Dobson M. B., during months of April and May. *J. Asiatic Soc. Bengal* 41: 273-290.

Ball, V. 1873. List of birds known to occur in the Andaman and Nicobar Islands. *Stray Feathers* I (2, 3&4): 51–90.

Barbe, P. 1846. Notice of the Nicobar Islands. *J. Asiatic Soc. Bengal* XV (Part I No 173 New Series No 89): 344–367.

Beavan, R.C. 1867. The avifauna of the Andaman Islands. Ibis 3(3): 314–334.

Bhaskar, S. 1981a. Travels in the Andamans & Nicobars. *Hornbill* 1981 (2): 14–22.

Bhaskar, S. 1981b. Travels in the Andamans and Nicobars. *Hamadryad* 6: 2–8.

Bhopale, N. 2010. Additions to the avifauna of the Indian Subcontinent - "White-faced" Plover *Charadrius dealbatus* from Andaman and Nicobar Islands, India. *J. Bombay nat. Hist. Soc., 1*07: (1) 60–61.

BirdLife International 2000. Threatened birds of the world. 1st edition, Stattersfield, A. J., Capper, D. R., Dutson, G. C. L., Evans, M. I., McClellan, R. K., Peet, N. B., Shutes, S. M., Stuart, T. E. H., Tobias, J. A. & Wege, D. C. (eds.). Cambridge, UK: Lynx Edicions & BirdLife International.

BirdLife International 2019. Handbook of the Birds of the World and BirdLife International digital checklist of the birds of the world. Version 4. Available at: http://datazone.birdlife.org/userfiles/file/Species/ Taxonomy / HBW-BirdLife_Checklist_v4_Dec19. zip.

Blyth, E. 1845. Notices and descriptions of various new and little-known species of birds. *J. Asiatic Soc. Bengal,* 14: 546–602.

Blyth, E. 1846a. Notices and descriptions of various new and little-known species of birds. *J. Asiatic Soc. Bengal*, 15: 1–54.

Blyth, E. 1846b. Notes on the fauna of the Nicobar Islands. On collections by Mr. Barbe and Capt. Lewis. *J. Asiatic Soc. Bengal.* 15: 367–379.

Blyth, E. 1863. Zoology of Andaman Islands. Appendix (pp 345–367 with Tytler's notes) to Mouat (1863). *J. Asiatic Soc. Bengal* 32: 85– 89.

Blyth, E. 1866. Abstracts from letters from Capt. Blair. *Ibis* (2): 220– 221.

Burnham, M.P., Anderson D.R. & Laake, J.L. 1980. Estimation of density from line transect sampling of biological populations. *Wildl. Monogr*. No. 72. 202 pp.

Butler, A.L. 1899a. The birds of the Andaman and Nicobar Islands. Part I. *J. Bombay nat. Hist. Soc.* XII (2): 386–403.

Butler, A.L. 1899b. The birds of the Andaman and Nicobar Islands. Part II. *J. Bombay nat. Hist. Soc.* XII (3): 555–571.

Butler, A.L. 1899c. The birds of the Andaman and Nicobar Islands. Part III. *J. Bombay nat. Hist. Soc.* XII (4): 684–696.

Butler, A.L. 1900. The birds of the Andaman and Nicobar Islands. Part IV. *J. Bombay nat. Hist. Soc.* XIII (1): 144–154.

Chandra, K. & Kumar, S. 1994a. Observations on avifauna of Great Nicobar Islands, India. *Indian Forester* 120(10): 953–955.

Chandra, K. & Rajan, P.T. 1994b. Observations on the avifauna of Mount Harriet National Park, South Andaman (A&N Islands). *Indian Forester* 122(10): 965–968.

Clement, P., Hathway, R., & Wilczur, J. 2000. Thrushes (Helm Identification Guides). Christopher Helm Publishers Ltd. pp. 229–232.

Clements, J.F., Schulenberg, T.S., Iliff, M.J., Roberson, D., Fredericks, T.A., Sullivan, B.L. and Wood, C.L. 2016. The eBird/Clements checklist of birds of the world: v2016. Downloaded from http://www.birds. cornell.edu /clementschecklist /download/

Comber, E. 1901. On the occurrence of *Coccystes coromandus* (The Red-winged Crested Cuckoo) in Bombay. *J. Bombay Nat. Hist. Soc*. 13(4): 696.

Cory, C.P. 1902. Some further notes on the Narcondam Hornbill (*Rhytidoceros narcondami*). J. Bombay Nat. Hist. Soc. XIV (2): 372.

Das, P.K. 1971. New records of birds from the Andaman and Nicobar Islands. *J. Bombay nat. Hist. Soc.* 68: 459-461.

Das, I. 1999a. Biogeography of the amphibians and reptiles of the Andaman and Nicobar Islands, India. pp 43-75. In: Ota, H. (Ed.), Proceeding of the International Symposium on diversity of reptiles, amphibians and other terrestrial animals on tropical islands: Origin, current status and conservation. June 1998, University of Ryukyus, Okinawa, Japan.

Das, I. 1999b. Noteworthy collection of mammals from Mount Harriet, Andaman Island, India. *J. South Asian Nat. Hist*., 4(2): 181-185.

Dasgupta, J.M. 1976. Records of birds from the Andaman and Nicobar Islands. *J. Bombay nat. Hist. Soc.*73: 222–223.

Dasgupta, J.M., Roy, S.B. and Datta, B.K. 2002. Endemic birds of India. *Rec. Zool. Surv. India. Occ. Paper* No. 200: 1–44.

Davidar, P. 1996. Conservation priorities for the Andaman Islands. *J. Bombay nat. Hist. Soc.* 93 (3): 555–558.

Davidar, P., Devi, S.M., Yoganand, T.R.K. & Ganesh, T. 1995. Reserve size and implications for the conservation of biodiversity in the Andaman Islands. In: Boyle, TJB., & Boontawee, B., (eds.) Measuring and monitoring biodiversity in tropical and temperate forests. Indonesia: CIFOR.

Davidar, P., Yoganand, T.R.K., Ganesh, T. & Joshi, N. 1996. An assessment of common and rare forest bird species of the Andaman Islands. *Forktail.* 12: 135–142.

Davidar, P., Yoganand, T.R.K. & Ganesh, T. 2001. Distribution of forest Davidar, P., T. R. K. Yoganand, T. Ganesh and N. Joshi. 1996. An assessment of common and rare forest bird species of the Andaman Islands. *Forktail* 12(1): 135-142.

Davidar, P., Yoganand, T.R.K., Ganesh, T. & Geetha-Nayak, K. 2007. Avifauna of Andaman Islands: Preliminary inventory and distributional patterns. *J. Bombay nat. Hist. Soc*. 104(3): 35-47.

DeSante, D.F. 1990. The role of recruitment in the dynamics of a Sierran subalpine bird communities. *American Natura*list 132: 429-445pp.

Ezhilarasi, N. & Vijayan, L. 2006. Birds of Chidiyatapu Biological Park, South Andaman. *Zoo's Print Journal* 21(12): 2517-2518.

Ferrar, M.L. 1931. Bird migration notes from Port Blair. *J. Bombay nat. Hist. Soc.* XXXV (2): 448–450.

Fleming, J.H. 1911. A new teal from the Andaman Islands. *Proc. Biol. Soc. Washington* 24: 215–216.

Flower, W.H. 1860. On the structure of the gizzard of the Nicobar Pigeon, and other granivorous birds. *Proc. of the Zool. Soc. London.* 1860: 330–334.

Frith, C.B. 1978. Short-tailed Shearwaters Puffinus tenuirostris in the Andaman Sea area, Indian Ocean. *Emu* 78: 95–97.

FSI, (Forest Survey of India) 2019. Indian State Forest Report 2019. Forest Survey of India, Dehradun Published by Ministry of Environment & Forests, Dehra Dun.

Gandhi, T. 2000. Prioritising sites for conservation in the Andaman and Nicobar Islands: With special reference to Fauna, pp. 82-93. In: Setting Biodiversity Conservation Priorities for India. Ed: Singh, S., Sastry, A.R.K. Mehta, R. and Uppal, V. WWF- India, New Delhi, India. Pp. xxvii + 707.

Gaston, A.J. 1973. Methods for estimating bird population. *Journal of the Bombay Natural History Society.* 72(2): 272-281.

Gibson-Hill, C.A. 1949. An immature Redtailed Bo'sun-Bird. *Bull. Raffles Museum*, 19: 100–104.

Gokulakrishnan, G. & Sivaperuman, C. 2016. Abundance, Distribution and Migration Chronology of Shorebirds of Andaman Islands. In: Proceedings of the International Conference on Climate change adaptation and biodiversity: Ecological sustainability and resource management for livelihood security (ICCB-2016), 8 – 10 December 2016. Pp. 150-163.

Gokulakrishnan, G., Dinesh, J. & Sivaperuman, C. 2014. Diversity and distribution of Shorebirds (Charadriiformes) in south Andaman. *J. Andaman Sci. Assoc*. 19(2):185-190.

Gokulakrishnan, G., Sivaperuman, C., Jaisankar, I., Velmurugan, A. & Dinesh, J. 2015. Species Abundance and Distributions of Bird Communities in Agroecosystems, South Andaman. *J. Andaman Sci. Assoc*. 20(2):151-163.

Gokulakrishnan, G., Sivaperuman, C., Rasmussen, P.C. & Parthipan, P. 2017. New distributional records of six bird species to Andaman and Nicobar Islands, India. BirdingAsia (In Press).

Grimmett, R., Inskipp, C. & Inskipp, T. 1998. Birds of the Indian subcontinent. Delhi: Oxford University Press.

Grimmett, R., Inskipp, C. & Inskipp, T. 2011. Pocket Guide to the Birds of the Indian Subcontinent. Christopher Helm, London, 384 p.

Hume, A.O. 1873. Novelties: *Rhyticeros narcondami*. *Stray Feathers* 1, 411–412.

Hume, A.O. 1873a. Additional remarks on the avifauna of the Andamans. Stray Feathers I (2,3&4): 304–310.

Hume, A.O. 1873b. Notes. Avifauna of the Islands of the Bay of Bengal. *Stray Feathers* 5: 421–423.

Hume, A.O. 1876. Additional notes on the avifauna of the Andaman Islands. *Stray Feathers* 4(4–6): 279–294.

Hussain, S.A. 1977. Narcondam - Island of the hornbills. Hornbill Inaugural: 26–30.

Hussain, S.A. 1984. Some aspects of the biology and ecology of Narcondam Hornbill (*Rhyticeros narcondami*). *J. Bombay nat. Hist. Soc*. 81(1): 1–18.

Hussain, S.A. 1991. Some urgent considerations for the conservation of Narcondam Island. *Newsletter for Birdwatchers* 31(5-6): 6.

Hussain, S.A. 1992. An action plan for rehabilitating Narcondam Hornbill. *Zoos' Print* VI (1): 1–2.

Hussain, S.A. 1993. The biology and ecology of the Narcondam Hornbill. *Hornbill* 1993 (4): 27–29.

IIRS 2003. Biodiversity characterization at landscape level in Andaman and Nicobar Islands using satellite remote sensing and geographic information system. Dehradun, India: Department of biotechnology, Government of India and Department of Space, Government of India.

Islam, Z. & Rahmani, A.R. 2004. Important Bird Areas in India. Priority sites for conservation. 1st ed. Mumbai: Indian Bird Conservation Network: Bombay Natural History Society and BirdLife International (UK).

IUCN, 2020. *The IUCN Red List of Threatened Species. Version 2020-2*. https://www.iucnredlist.org. Downloaded on 09 July 2020.

Jayaraj, R.S.C. & Andrews, H.V. 2005. Andaman & Nicobar Islands Union Territory biodiversity strategy and action plan, 142 pp. India: Prepared under the National Biodiversity Strategy and Action Plan- India, ANET/ GOI-UNDP/A &N D E & F. Universities Press.

Kazmierczak, K. 1991. Andaman update. *O. B. C. Bull.* 13 (July): 35.

Krishnan, S.M. 1954. Occurrence of Red winged Crested Cuckoo (*Clamator coromandus*) in Madras. *J. Bombay Nat. Hist. Soc*. 52 (1): 210.

Kulkarni, S. and Chandi, M. 2003. Note on breeding of Andaman Teal Anas gibberifrons in South Andaman Islands, India. *J. Bombay nat. Hist. Soc.* 100 (1): 112–113.

Lever, C. 1987. *Naturalized birds of the world*. Harlow: Longman Scientific & Technical. pp. i–xx, 1–615.

Manchi, S.S. 2013. Records of the Andaman Barn-owl *Tyto deroepstorfii* in North, and Middle Andaman Islands. *Indian Birds* 8 (3): 66–67.

Mamannan, M.A.R. & Vijayan, L. 2009. Three new bird records from the Andaman Islands, India. *Forktail* 25: 154–155.

Mees, G.F. 1981. The Sparrow-Hawks (Accipiter) of the Andaman Islands. *J. Bombay nat. Hist. Soc.* 77 (3): 371–412 (1980).

Mukherjee, A.K. 1981. Status of the Andaman Teal *Anas gibberifrons albogularis* (Hume). *Proc. Wildlife Workshop*: 121–122.

Mukherjee, A.K. & Dasgupta, J.M. 1975. Taxonomic status of the Nicobar Emerald Dove, *Chalcophaps augusta* Bonaparte, 1850 (Aves: Columbidae) *Proc. Zool. Soc. Calcutta,* 28: 133–135.

Oberholser, H. 1915. A review of the subspecies of the Ruddy Kingfisher *Entomothera coromanda* (Linnaeus). *Proc. United States Nat. Mus.,* 48 (2090): 639–657.

Oberholser, H. 1917. The birds of the Anamba Islands. Bull. United States Nat. Mus., 98: 1–75.

Oberholser, H. 1919. The races of the Nicobar Megapode *Megapodius nicobariensis* Blyth. *Proc. United States Nat. Mus*. 55 (2278): 399–402.

Osmaston, B.B. 1905. A visit to Narcondam. *J. Bombay nat. Hist. Soc.* 16: 620–622.

Osmaston, B.B. 1906a. Notes on Andaman birds with accounts of the nidification of several species whose nests and eggs have not been hitherto described. *J. Bombay nat. Hist. Soc.* XVII (1): 156–163.

Osmaston, B.B. 1906b. Mangroves and Paroquets. *J. Bombay nat. Hist. Soc.* XVII (1): 240.

Osmaston, B.B. 1906c. Notes on Andaman birds, with accounts of the nidification of several species whose nests and eggs have not been hitherto described. Part II. *J. Bombay nat. Hist. Soc.*XVII (2): 486–491.

Osmaston, B.B. 1907. A visit to South Sentinel Island. *J. Bombay nat. Hist. Soc.* XVIII (1): 201–202.

Osmaston, B.B. 1908. A visit to Barren Island, Andaman. *J. Bombay nat. Hist. Soc.* 18: 357–359.

Osmaston, B.B. 1932. Some Andaman birds. *J. Bombay nat. Hist. Soc*. 35 (4): 891–893.

Osmaston, B.B. 1933. Some Andaman birds. *J. Bombay nat. Hist. Soc.,* 35: 891–893.

Osmaston, B.B. 2001. Birds in the Andamans (extracts from the diaries of B.B. Osmaston). *Newsletter for Birdwatchers* 41 (3): 34–35.

Pal, T., Mitra, S.K., Sengupta, S., Katari, A., Bandopadhyay, P.C. and Bhattachrya, A. K. 2007. Dacite-andesites of Narcondam volcano in the Andaman Sea: An imprint of magma mixing in the inner arc of the the Andaman-Java subduction system. *Journal of Volcanology and Geothermal Research* 168: 93-113.

Pande, S. 2007. ELA Foundation's Third Endemic and Pelagic Bird Survey (8th to 20th January, 2007), Andaman and Nicobar Islands in the Bay of Bengal conducted by ELA Foundation, Pune & Ecological Society, Pune with assistance from Indian Coast Guard. Unpublished report submitted to Director General Coast Guard, New Delhi.

Pande, S., Sant, N. & Pednekar, S. 2011. Avifaunal survey of South- and Middle-Andaman Islands, November 2009. *Indian Birds* 7 (4): 104–106.

Pande, S., Sant, N. Ranade, S., Pednekar, S., Mestry, P., Deshpande, P., Kharat, S. & Deshmukh, V. 2007. Avifaunal survey of Andaman and Nicobar Islands, January 2007. *Indian Birds* 3 (5): 162–180.

Poonswad, P., Kemp, A., & Strange, M. 2013. Hornbills of the world: a photographic guide. Singapore: Draco Publishing & Distribution Pte. Ltd. Pp. 1–212.

Prain, D. 1892. Remarks on the fauna of Narcondam and Barren Island. *Proc. Asiatic Soc. Bengal* 1892: 109–121.

Prakash, V. 1995. Conservation of the Narcondam Hornbill. In: Avian Conservation in India. 44–45.

Prakash, V., Prakash, N.V. & Clark, W.S. 1994. Oriental Honeybuzzard *Pernis ptilorhynchus*: a new species for the Andaman Islands. Forktail 9: 157–158.

Prashanth, M. & Veenakumari, K. 1996. Perspectives on the zoogeography of the Andaman and Nicobar Islands, India. *Malayan Nature J.* 50: 99–106.

Praveen, J., Jayapal, R. & Pitie, A. 2016. A checklist of the birds of India. *Indian Birds* 11 (5&6): 113 – 172.

Praveen, J., Jayapal, R. & Pitie, A. 2018. Taxonomic updates to the checklist of birds of India and the South Asian region—2018. Indian BIRDS. 14.

Rajan, P. & Pramod, P. 2011a. First records of European Roller *Coracias garrulus* from the Andaman Islands, India. *BirdingAsia* 16 (2011): 106–107.

Rajan, P. & Pramod, P. 2011b. Common birds of Andaman Islands with special emphasis to introduced birds. In: Status of Indian birds and their conservation: First Interna-tional Conference on Indian Ornithology (ICIO) - 2011. Bhupathy, S., Prusty, B. A. K., Kumara, H.N., Jayaraj, R.S.C., Quadros, G., & Pramod, P., (Eds.). Coimbatore, India: Salim Ali Centre for Ornithology and Natural History: Pp. 262–264.

Rajan, P. & Pramod, P. 2013. Introduced birds of the Andaman & Nicobar Islands, India. *Indian Birds* 8 (3): 71-72

Rajeshkumar, S., Raghunathan, C. & Maheswaran, G. 2014. Blue-and-white Flycatcher *Cyanoptila cyanomelana*: First record for Andaman & Nicobar Islands, India. *Indian Birds,* 9 (4): 104–105.

Raju, K.S.R.K. 1979. Occurrence of Red winged Crested Cuckoo *Clamator coromandus* in Vishakhapatnam. *Newsletter for Birdwatchers*. 19 (12): 11.

Raman, T.S.R., Mudappa, D., Khan, T., Mistry, U., Saxena, A., Varma, K., Ekka, N., Lenin, J., & Whitaker, R. 2013. An expedition to Narcondam: observations of marine and terrestrial fauna including the island-endemic hornbill. *Current Science*, Vol. 105, No. 3 346

Rao, N.V.S., Das, A.K. & Mitra, S.C. 1980. On freshwater mollusks of Andaman and Nicobar Islands. *Rec. Zool. Surv. India* 77: 215-246.

Rasmussen, P.C. 1998 A new Scops Owl from Great Nicobar Island. *Bull. B.O.C.* 118 (3): 141–153.

Rasmussen, P.C. 2000. On the status of the Nicobar Sparrowhawk *Accipiter butleri* on Great Nicobar Island, India. *Forktail* 16: 185–186.

Rasmussen, P.C. 2005a. On producing Birds of South Asia. *IndianBirds* 1 (3): 50–56.

Rasmussen, P.C. 2005b. Biogeographic and conservation implications of revised species limits and distributions of South Asian birds. Zoologische Mededelingen, Leiden 79-3 (13): 137–146.

Rasmussen, P.C. 2005c. On producing Birds of South Asia. *IndianBirds* 1 (3): 50–56.

Rasmussen, P.C. & Anderton, J.C. 2005. Birds of South Asia. The Ripley Guide. Volumes 1 & 2. Washington, D.C. and Barcelona: Smithsonian Institution and Lynx Edicions. 1061 p.

Rasmussen, P.C. & Anderton, J.C. 2012. Birds of South Asia: the Ripley guide. 2nd ed. Washington, D.C. and Barcelona: Smithsonian Institution and Lynx Editions. 2 Vols. pp. 1–378; 1-683.

Relton, A. 1999. Birding in the Andamans (Abstract). *Newsletter for Birdwatchers* 38 (6): 102.

Richmond, C.W. 1902. Birds collected by Dr. W. L. Abbot and Mr. C. B. Kloss in the Andaman and Nicobar Islands. *Proc. U. S. Nat.Mus.,* 25: 287–314.

Ripley, S.D. & Beehler, B.M. 1989. Ornithographic affinities of the Andaman and Nicobar Islands. *J. Biogeogr.,* 16(4): 323- 332.

Robertson, A.L.H. 1995. Occurrence of some Pelagic Seabirds (Procellariiformes) in waters off the Indian subcontinent. *Forktail,* 10: 129–140 (1994).

Robson, C. 2008. Birds of South-east Asia. New Holland Publishers, UK.

Robson, C. 2011. Field Guide to the Birds of South-East Asia Paperback. New Holland Australia(AU); 3rd Revised edition. 544 p.

Saha, S.S. & Dasgupta, J.M. 1980. The Malayan Serpent Eagle *Spilornis cheela malayensis* (Swann) in the Great Nicobar Island, an addition to the Indian avifauna. *Rec. Zool. Surv. India* 77: 89–91.

Saldanha, C.J. 1988. A select bibliography on the Andaman and Nicobar Islands for an environmental impact assessment. Bangalore, India: Centre for taxonomic studies, St. Joseph's College.

Saldanha, C.J. 1989. Andaman, Nicobar & Lakshadweep: an environmental impact assessment. New Delhi: Oxford University Press & IBH Publ. Co.

Samaraweera, P. 2006. Oriental Plover Charadrius veredus: second record in Sri Lanka, third in South Asia. *Ceylon Bird Club Notes* 2006 (November): 148–151.

Sankaran, R. 1993. The status and conservation of the Nicobar Scrubfowl *Megapodius nicobariensis*. Coimbatore: SACON.

Sankaran, R. 1995a. The distribution, status and conservation of the Nicobar Megapode Megapodius nicobariensis. Biological Conservation 72(1): 17–26.

Sankaran, R. 1995b. Distribution, status and conservation of the Nicobar Megapode. In: Avian Conservation in India. 43–44. 43–44. Vijayan, L. (ed.) Coimbatore: SACON.

Sankaran, R. 1995c. Impact assessment of nest collection on the Edible-nest Swiftlet (*Collocalia fuciphaga*) in the Nicobar Islands. Occasional report. Coimbatore: Sálim Ali Centre for Ornithology & Natural History.

Sankaran, R. 1995d. The decline of the Edible-nest Swiftlet in the Nicobar Islands. *OBC. Bull.*, 22: 51–54.

Sankaran, R. 1995e. The Nicobar Megapode and Other Endemic Avifauna of the Nicobar Islands. Status and Conservation. Coimbatore: Sálim Ali Centre for Ornithology and Natural History.

Sankaran, R. 1997. Developing a protected area network in the Nicobar Islands: the perspective of the endemic avifauna. *Biodiversity and Conservation*, 6 (3): 797–815.

Sankaran, R. 1998. The Narcondam Hornbill - Conservation Measures. A Preliminary Report.

Sankaran, R. 1998a. An annotated list of the endemic avifauna of the Nicobar Islands. *Forktail* 13 (February): 17–22.

Sankaran, R. 1998b. The impact of nest collection on the Edible-nest Swiftlet (*Collocalia fuciphaga*) in the Andaman and Nicobar Islands. Report to IUCN. Coimbatore: Sálim Ali Centre for Ornithology and Natural History.

Sankaran, R. 1998c. The status and conservation of the Narcondam Hornbill (Abstract). National seminar on wildlife conservation, Research and Management. Wildlife Institute of India, Dehra Dun.

Sankaran, R. 1998d. The Narcondam Hornbill – Conservation Measures. A Preliminary Report.

Sankaran, R. 1998e. Clear Felling of Primary Rain Forest at the Lighthouse at Indira Point, Great Nicobar Island – Ameliorative Measures.

Sankaran, R. 2001.The status and conservation of the Edible-nest Swiftlet (*Collocalia fuciphaga*) in the Andaman and Nicobar Islands. *Biological Conservation* 97: 283–294.

Sankaran, R. 2005. Impact of the earthquake and the tsunami on the Nicobar Islands. Pp. 10–77. In: Kaul, R., & Menon, V., (Eds). The ground beneath the waves: post-tsunami impact assessment of wildlife and their habitats in India. Vol 2. New Delhi: Wildlife Trust of India.

Sankaran, R. & Manchi, S. 2008. In-situ and ex-situ conservation of the Edible–nest Swiftlet *Collocalia fuciphaga* in the Andaman & Nicobar Islands. 18–19. Annual Report 2007–08. Coimbatore: SACON.

Sankaran, R. & Sivakumar, K. 1999. Preliminary results of ongoing study of the Nicobar Megapode *Megapodius nicobariensis* Blyth. *Zoologiszhe Verhandelingen, Leiden,* 327: 75–90.

Sankaran, R. & Vijayan, L. 1993. The avifauna of the Andaman and Nicobar Islands: A review and the current scenario. Pp. 255–271. In: Verghese, A., S. Sridhar and A.K. Chakravarthy (Eds): Bird Conservation: Strategies for the Nineties and Beyond. Ornithological Society of India, Bangalore.

Santharam, V. 1991. Barn Owls as biological control agents in the Andamans. *Newsletter for Birdwatchers,* 31 (5-6): 9.

Santharam, V. 1996. Birdwatching in the South Andamans. *Newsletter for Birdwatchers,* 35 (6): 104–105.

Santharam, V. 1997. Birdwatching in the South Andamans. Part- II. *Blackbuck* 11 (4): 87–97.

Saxena, A. 1994. Sighting of Christmas Island Frigate Bird (*Fregata andrewsi*) Mathews in the Andamans, *J. Bombay Nat. Hist. Soc*. 91 (1): 138.

Sebastian, A.C. 1991. The barn Owl - man's silent ghostly friend. *Newsletter for Birdwatchers* 31 (5-6): 9–10.

Sivakumar, K. 2000. A study on breeding biology of the Nicobar Megapode *Megapodius nicobariensis*. Ph.D, Thesis, Bharathiyar University Tamil Nadu.

Sivakumar, K. 2003a. Megapode: A fascinating bird of Nicobar Islands. *Mistnet* 4 (1): 6.

Sivakumar, K. 2003b. Some observations on the breeding biology of birds on Great Nicobar Island, India. *Forktail* 19: 130–131.

Sivakumar, K. 2007. Impact of tsunami on the Nicobar Megapode. Dehra Dun: Wildlife Institute of India.

Sivakumar, K. & Sankaran, R. 2002. New records of birds from the Andaman and Nicobar Islands. *Forktail* 18(1): 149-150.

Sivakumar, K. & Sankaran, R. 2003. The incubation mound and hatching success of the Nicobar Megapode *Megapodius nicobariensis* Blyth. Tamil Nadu, 100 (2&3): 375–387.

Sivakumar, K. & Sankaran, R. 2005a. Natural history notes on chicks of the Nicobar Megapode *Megapodius nicobariensis*. Tamil Nadu, 101 (3): 452–452 (2004).

Sivakumar, K. & Sankaran, R. 2005b. The diet of the Nicobar Megapode *Megapodius nicobariensis*, in Great Nicobar Island. Tamil Nadu, 102 (1): 105–106.

Sivaperuman, C., Venkatraman, C., & Raghunathan, C. 2010. Avifauna of Andaman and Nicobar Islands: An Overview. pp. 399-412. In: Recent Trends in Biodiversity of Andaman and Nicobar Islands. Ramakrishna, Raghunathan, C and Sivaperuman, C. (Eds.). Zoological Survey of India, Kolkata.

Sivaperuman, C., Shah, S.K., Rajan, P.T. & Venkataraman, K. 2012. New record of Common Coot *Fulica atra* 1758 from Andaman and Nicobar Islands. *Tamil Nadu,* 103: 199-200.

Sridharan, B., Mohanty, N.P., Anujan, K. & Nelaballli, S. 2017. Violet Cuckoo *Chrysococcyx xanthorhynchus* in the Andaman Islands. *Indian Birds,* 13 (2): 46–50.

St. John, J.H. 1898. Some notes on the Narcondam Hornbill, etc. (Rhytidoceros narcondami). *J. Bombay Nat. Hist. Soc.* XII (1): 212– 214.

St. John, J.H. 1898. Some notes on Narcondam Hornbill etc. *J. Bombay Nat. Hist*. Soc. 12: 212–214.

Stapylton, J.M. 1933. Early arrival of Snipe in the Andamans. *J. Bombay Nat. Hist.* 36 (2): 507–508.

Stapylton, J.M. 1934b. Migration and decrease of Snipe in the Andamans. *J. Bombay Nat. Hist. Soc.,* XXXVII (2): 491–492.

Stapylton, J.M. 1934a. Early arrival of Snipe in the Andamans. *J. Bombay Nat. Hist. Soc*., XXXVII (1): 224.

Stattersfield, A.J., Crosby, M.J., Long, A.J. & Wege, D.C. 1998. Endemic bird areas of the world. Cambridge: BirdLife International.

Steadman, D.W. 1991. The identity and taxonomic status of Megapodius stairi and M. burnabyi (Aves: Megapodiidae). *Proc. Biol. Soc. Washington* 104: 870–877.

Sundaramoorthy, T. 2010. Bird diversity of Andaman and Nicobar Islands. *Eco News* 16(1): 3-8.

Thangam, E.S. 1966. Introduction of some birds in Andaman & Nicobar Islands during 1960-1965. *Indian Forester* 92: 441– 446.

Thiollay, J.M. 1997. Distribution and abundance patterns of bird community and raptor populations in the Andaman archipelago. *Ecography,* 20: 67–82.

Thompson, S. 2014. Website: http://ebird.org/ebird/view/checklist/S24463247. [Accessed on: 03 December, 2014]

Thothathri, K. 1962. Contributions to the flora of the Andaman and Nicobar Islands. *Bull. Bot. Surv. India,* 4: 281-296.

Tikader, B.K. 1984. Birds of Andaman & Nicobar Islands. Calcutta: Zoological Survey of India.

Tytler, R.C. 1864. Description of a new species of *Paradoxurus* from the Andaman Islands. *J. Asiatic Soc. Bengal,* XXXIII (Part II Series No 294 No II): 188.

Tytler, R.C. 1867. The avifauna of the Andaman Islands. *Ibis* (2) 3: 314–334.

Unnithan, S. 1996. Variations in Olivebacked Sunbirds *Nectarinia jugularis* (Linnaeus) of Andaman, Car, Central and Great Nicobar Island. *J. Bombay Nat. Hist. Soc,* 93 (2): 297–298.

Vijayan, L. 1993. Status and conservation of some rare endemic avifauna of the Andaman Islands - a preliminary survey. Coimbatore: Salim Ali Centre for Ornithology & Natural History. Unpublished report.

Vijayan, L. 1996. Status and conservation of the Andaman Teal *Anas gibberifrons albogularis*. Gibier Faune Sauvage, *Game Wildl*., 13 (1): 831–842.

Vijayan, L. 1999. Endemic birds of the Andaman Nicobar Islands and their conservation. Pp 20–30. In: Prabhakaran, J., (Ed.) Environmental education needs of the Andaman & Nicobar Islands. Proceedings of the conference held at Port Blair on March 5 & 6, 1997. Chennai: C P R Environmental Education Centre.

Vijayan, L. 2006. Ecology and conservation of the Andaman Teal. *J. Bombay Nat. Hist. Soc.* 103 (2–3): 231–238.

Vijayan, L. 2007. Ecology and conservation of the Andaman Teal. *J. Bombay Nat. Hist. Soc.,* 103 (2&3): 231–238 (2006).

Vijayan, L. & Ezhilarasi, N. 2007. Status and ecology of the Andaman Crake. 100 pp. Final report of the project. Coimbatore: SACON.

Vijayan, L., Sankaran, R., Sivakumar, K. & Murugan, V. 2000. A study on the ecology, status and conservation perspectives of certain rare endemic avifauna of the Andaman & Nicobar Islands: Final Report. Salim Ali Centre.

Vijayan, L., Prasad, S.N., Mamannan, M.A.R., Kaushik, P. & Giriraj, A. 2005. Avifaunal diversity of the Andaman Islands and their conservation. 84 pp. Final report. Coimbatore: SACON.

Vivek, R. & Vijayan, V.S. 2003. Ecology and conservation of the Narcondam Hornbill (Aceros narcondami) at Narcondam Island Sanctuary, India. Interim Report, Sálim Ali Centre for Ornitho- logy and Natural History, Coimbatore.

Voous, K.H. 1965. Notes on sea-birds 14. White-faced Storm Petrels in the Indian Ocean: correction and additions. *Ardea,* 53: 237.

Wahal, A.K. 1995. Birds of the Andaman and Nicobar Islands and issues related to their conservation. In: Avian Conservation in India. 55–56.

Walden, A. 1866. Notes on birds collected in Tenasserim and in Andaman Islands. *Proc. Zool. Soc. London* 1866: 537–556.

Walden, A. 1873. On a collection of birds from the Andaman Islands. *Ibis* (3) 3: 296–321.

Whistler, H. 1940. The Andaman Large Cuckoo-Shrike. *Ibis* 4 (4): 731.

Whitaker, R. 1976. Birding in the Andamans. *Newsletter for Birdwatchers* 16 (10): 3–5.

Whitaker, R. 1985. Endangered Andamans. New Delhi: Environmental Services Group, WWF–India, and MAB India, Department of Environment.

Whitaker, R. 2000. Saving the Andamans. *Sanctuary Asia* XX (1): 22–26.

Whitehead, J.H. 1912. Woodcock *Scolopax rusticula* in South Andamans. *J. Bombay Nat. Hist. Soc.* XXI (3): 1085.

Wickham, P.F. 1910. A note on the nesting of the Besra Sparrow Hawk (*Accipiter virgatus*) and the Andaman Nightjar (*Caprimulgus andamanicus*) in the Andamans. *J. Bombay Nat.Hist. Soc.* XIX (4): 992–993.

Wilson, N.F. 1904. The Oceanic, or Andaman Teal (*Nettium albigulare*). *J. Bombay Nat. Hist. Soc.* XV (3): 525–526.

Yahya, H.S.A., & Zarri, A.A. 2002a. White Tern (*Gygis alba*) sighted at Narcondam Island, Bay of Bengal, India. *Forktail,* 18: 148–149.

Yahya, H.S.A., & Zarri, A.A. 2002b. Status, ecology and behaviour of Narcondam Hornbill in Narcondam Island, Andaman & Nicobar Island, India. *J. Bombay nat. Hist. Soc.,* 99 (3): 434–445.

Zaibin, A.P., Sant, N., Krys, K. & Pramod, P. 2014. Grey-faced Buzzard *Butastur indicus* from Kamorta Island, Nicobar Islands, India: First photographic documentation. *Indian Birds,* 9 (4): 102–103.

Received : 14th February 2020 Accepted : 4th May 2020

Status and distribution of Wetland Birds in Tsunami inundated Wetlands of South Andaman

Sivaperuman, C[1] *., G. Gokulakrishnan[1] and S. Senthil Kumar[2]

[1]*Zoological Survey of India, Andaman and Nicobar Regional Centre, Haddo, Port Blair - 744 102, A & N Islands*

[2]*Indira Gandhi National Forest Academy, P.O New Forests, Dehra Dun – 248 006, Uttarakhand*

**Corresponding author: c_sivaperuman1@rediffmail.com*

Abstract

The Andaman and Nicobar islands is one of the major groups of islands of India, and rich in biodiversity with high endemism due to isolation, about 17 percent of flowering plants, 13 percent of faunal including 40 per cent of birds and 70 percent of butterflies. One hundred and twenty-two taxa of birds were recorded from the tsunami inundated wetlands. These belong to 27 Families under 11 Orders. Of the 122 species, 69 were winter migrant, 24 species were resident. Thirty four species of shorebirds were recorded during the period of the study. These belong to the order Charadriiformes and distributed into six families. The sighting of Chinese Egret from the Andaman Islands was the first record of the species from India and South Asia. As this wetland is coming under '*East-Asian Australasian Flyway*', protection of the migratory species is of highest priority. The wetland lands of Andaman are an ideal habitat for migratory and resident birds, especially for the winter visitors.

Keywords: Avifauna, Conservation, South Andaman, Wetlands

Introduction

Wetlands are amongst the most productive ecosystems on the Earth (Ghermandi et al., 2008), and provide many important services to human society (ten Brinketal., 2012). However, they are also ecologically sensitive and adaptive systems (Turner et al., 2000). Wetlands exhibit enormous diversity according to their genesis, geographical location, water regime and chemistry, dominant species, and soil and sediment characteristics (Space Applications Centre, 2011). Globally, the areal extent of wetland ecosystems ranges from 917 million hectares (mha) (Lehnerand Döll, 2004) to more than 1275 mha (Finlayson and Spiers,1999) with an estimated economic value of about US $ 15 trillion a year (MEA,2005). Wetlands are considered to have unique ecological features which provide numerous products and services to humanity (Prasad et al., 2002). Ecosystem goods provided by the wetlands mainly include: water for irrigation; fisheries; non-timber forest products; water supply; and recreation. Major services include: carbon sequestration, flood control, ground water echarge, nutrient removal, toxic sretention and biodiversity maintenance (Turneret al., 2000).

Wetlands are important in supporting species diversity. Some vertebrates and invertebrates depend on wetlands for their entire lifecycle while others only associate with the seareas during particular stages of their life. Because wetlands provide an environment where photosynthesis can occurand where the recycling of nutrients can take place, they play a significant role in the support of food chains (Adams, 1988). In India, lakes, rivers and other fresh water bodies support a large diversity of biota representing almost all taxonomic groups. The total numbers of aquatic plant species exceed 1200 and they provide avaluable source of food, especially for water fowl (Prasad et al., 2002).

Tropicsl island birds have been estimated to possess extinction risks up to 40 times greater than mainland species due to their restricted ranges and population sizes, and consequently are highly vulnerable to habitat destruction (Trevino *et al.,* 2007; Pimm *et al.,* 1995). Indeed, over 90 per cent of recent bird extinctions have been island endemics (Clements, 2007; Birdlife International, 2004) and almost 40 per cent of species currently listed as threatened by the IUCN are restricted to oceanic islandsa highly disproportionate figure given the small land mass and contribution to global avian richness these ecosystems represent (IUCN, 2009; Trevino *et al.,* 2007; Johnson and Stattersfield, 1990; Martin and Blackburn, 2010).

Information on the avifauna of an area is a prerequisite to assess the status of birds and the habitat quality with specific attention to indicator species including the rare, endangered and endemic species. Birds are one of the best indicators of the health of an ecosystem. They are highly mobile and easily observed indicators of change in the environment (Holmes *et al*., 1986). Many wetland species also play a role in the control of agricultural pests, while some species are themselves considered pest of certain crops. After fish, birds are probably the most important faunal group that attract people to wetlands. Loss of wetland habitats through direct and indirect modifications and non-sustainable harvesting of water birds for human needs have led to decline in several water bird populations and a number of species (Jin-Han Im *et al*., 2001). The number of water birds using a particular habitat is related to types and quality of habitats, abundance and availability of food and level of disturbance. Monitoring of water birds can thus provide valuable information on the status of wetlands and can be a key tool for increasing the awareness of importance of wetland and conservation values. In this paper, the status, occurrence and species composition of avifauna recorded from the tsunami inundated wetlands are elucidated.

Wetlands of Andaman

The mega undersea earthquake of 26 December 2004, and the consequent tsunami, has changed the landscape of Andaman and Nicobar Islands. About 40 km^2 of land, in many locations, has been directly or indirectly affected by this event, resulting in a drastic change in land use patterns (Roy *et al.,* 2009). The subsidence of the South Andaman Island by almost one meter had caused high tides that reached inland and flooded the low-lying flatlands, including agricultural lands and human habitations (Chatterjee, 2006). Prior to the tsunami, local inhabitants utilised the tsunami-inundated areas of South Andaman Islands for agriculture (Table 1; Fig. 1). These inundated wetlands became opportunistic feeding grounds for migratory waders and resident waterbirds.

The Andaman and Nicobar Islands, especially the South Andaman Islands is one of the most human-influenced areas. The inundation of agricultural lands by the tsunami has led to them being abandoned by the people, as they have turned into wetlands (Malik *et al.,* 2006; Dam Roy et al., 2017). Wetlands have long attracted the attention of public and scientists because of the charm, copiousness, visibility and social behavior of the waterbirds, as well as for their recreational and economic importance. Recently, waterbirds have become of interest as indicators of wetland qualityand as parameters of restoration success andregional biodiversity. Each year, large number of water birds that breeds in areas of Europe and North and Central Asia in summer under takes migratory journey along major river valleys tospend the winter in more hospitable shelters insoutherly latitudes. As the wetlands in northernareas become frozen due to the onset of winterand the food disappears under snow cover.

Table 1: Characteristics of wetlands of South Andaman Islands

Wetlands	Garacharma	Sippighat	Chouldhari	Ograbraj	Stewartgunj
Location	11° 37.055' N; 92° 42.496' E	11° 36.749' N; 92° 41.583' E	11° 37.350' N; 92° 40.108' E	11° 39.463' N; 92° 39.785' E	11° 43.617' N; 92° 42.826' E
Total Area		1.1411 km^2		0.6348 km^2	0.3428 km^2
Submerged area		0.7186 km^2		0.2473 km^2	0.2599 km^2
No. of Wetlands	5	5	4	3	2

Description	Grassland, Marsh Area, Mudflat, Shallow water, Mangrove and Littoral Forest	Floating Vegetation, Grassland, Marsh Area, Mudflat, Shallow water, Mangrove and Littoral Forest (0.5m water depth during high tide). One side has mangroves and the Andaman Trunk Road borders the other.	Shallow-water/ tidal mudflat /cultivation land/ Mangrove	Tidal mudflat, tsunami inundated area with dead trees, surrounded by human settlement, mangrove. A road has divided this wetland into two sections.	Grassland, some parts grass with stagnant water. This wetland is surrounded by human settlement.
Main Threats for birds	Hunting or poaching, logging and introduction of exotics, dumping domestic sewage and landfilling.	Illegal hunting of birds by local people with air guns, kayaking, dumping domestic sewage, landfilling, fishing activities. Reclamation by local people for construction.	Fishing boats, pollution, poaching and fishing	Dumping waste materials Pollution, poaching and fishing, and landfilling.	Degradation of wetland; land filling, dumping of waste materials especially

Migratory Flyways

Water birds are an important component of most of wetland environment, as these occupy several trophic levels in the food web of wetland nutrient cycles. The Strategy adopts the Ramsar Convention definition for waterbirds "*Birds ecologically dependent on wetlands*" and includes recognized groups popularly known as wildfowl, waterfowl and shorebirds and waders. In addition to these groups, other species groups dependent on wetlands are passerines. Several wetlands in the coastal floodplains are important for the migratory waders and ducks. As the shorebirds use varied habitats like estuaries, riverbanks, paddy fields, etc. foraging and roosting sites are readily available. Migration remains one of the most compelling aspects of the avian world. Twice a year, billions of birds migrate vast distances across the globe. Typically, these journeys follow a predominantly north-south axis, linking breeding grounds in arctic and temperate regions with non-breeding sites in temperate and tropical areas. The routes followed by migratory birds on their journeys between their breeding and wintering places are known as flyways.

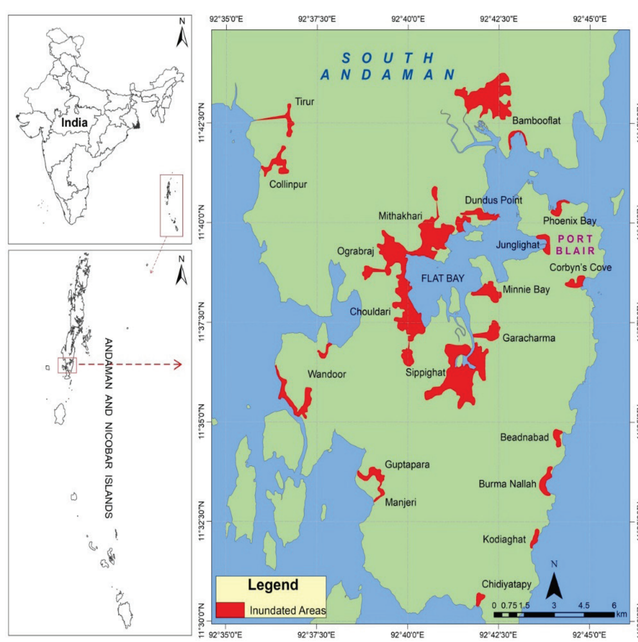


Fig. 1: Map of tsunami inundated wetlands of south Andaman

Boere and Stroud (2006) defined the flyways as *"the biological systems of migration paths that directly link sites and ecosystems in different countries and continents"*. The International Wader Study Group indentifies eight multiple-species flyways that broadly describe the migrations of waders (Boere and Stroud, 2006). Of these, fivearerecognized as major flyways for migratory shorebirds namely, Central Pacific Flyway, American Flyway, African-West Eurasian Flyway, Central Asian Flyway and East Asian-Australasian Flyway. These global flyways are a considerable over simplification of the complex journeys undertaken by the world's 2,274 migratory species (Kirby, 2010). India is known to support 1232 species of bird species, out of these 257 species are water birds. East Asian-Australasian Flyway (EAAF) extends from Arctic Russia and North America to the southern limits of Australia and New Zealand. It encompasses large parts of East Asia, all of Southeast Asia and includes eastern India and the Andaman and Nicobar Islands. The migratory birds arrive in Andaman and Nicobar Islands during August/September and stay in the area up to March/April.

More than 50 million migratory waterbirds including 8 million waders are using the EAAF annually. Many waders travel all the way from their high arctic breeding grounds to spend the northern winter in the temperate latitudes of the southern hemisphere. For the Bar-tailed Godwit *Limosa lapponica*, this can entail an 11,000 km non-stop flight from Alaska to New Zealand (Gill*et al*., 2009). Some species, such as Red-necked Stint *Calidris ruficollis* and Spotted Greenshank *Tringa guttifer* (EN) also cross Bangladesh to spend the winter in eastern India.

Methods

The species compositions of birds were computed from the data obtained through daily census and field observations. Birds were classified as migratory and resident species based on the occurrence data and published literature. Globally threatened species of birds were identified based on (BirdLife International, 2019). Feeding and guild composition were collected from the available literature (Ali and Ripley, 1983). Bird species have been categorised as aquatic feeders, insectivores, granivores, nectar-frugivores, carnivores, frugivores and omnivores. They were also classified as water birds, waders and terrestrial birds based on their habitat use.

Results

Occurrence of species

One hundred and twenty-two taxa of birds were recorded from the tsunami inundated wetlands. These belong to 27 Families under 11 Orders. Of the 122 species, 69 were winter migrant, 24 species were resident (Table 2).

Distribution of bird species in the intensive study area

The highest species of birds were recorded from Sippighat (98), followed by Ograbraj (96), Garacharma (95), Chouldhari (81), Chidiyatappu (73), Stewartgunj (68) and Shoal Bay (60) (Table3).

Shorebirds

Waders constitute an important group of wetland species. These birds depend heavily on shallow waters and mud flats, normally recorded from September onwards in the tsunami inundated wetlands. Details on the occurrence of waders in the four intensive study sites are presented in Table 4. The highest species of waders was recorded from Sippighat (32) followed by Garacharma (31), Ograbraj (30), Chouldhari (25), Stewartgunj (19), Shoal Bay (17), and Chidiyatappu (14). Pacific Golden Plover, Lesser Sand Plover, Greater Sand Plover, Pintail Snipe, Eurasian Whimbrel, Eurasian Curlew, Common Redshank, Wood Sandpiper, Common Sandpiper, Rufous-necked Stint, Lon-toed Stint, Curlew Sandpiper and Oriental Pratincole were recorded from all the intensive study sites in the three migratory seasons.

Table 2. List of birds recorded from the tsunami inundated wetlands

Sl. No.	Common Name	Scientific Name	Residential Status	IUCN Status	Abundance Status	Food	Stratum	Behaviour
	Waterbirds							
	Podicipediformes							
	Podicipedidae							
1	Little Grebe	*Tachybaptus ruficollis* (Pallas, 1764)	WM	LC	R	C	F	DC
	Procellariiformes							
	Procellariidae							
2	Wedge-tailed Shearwater	*Puffinus pacificus* (Gmelin, 1789)	WM	LC	U	C	O	AAqC
	Pelecaniformes							
	Sulidae							
3	Red-footed Booby	*Sula sula* (Linnaeus, 1766)	V	LC	R	C	O	AAqC
	Phalacrocoracidae							
4	Little Cormorant	*Microcarbo niger* (Vieillot, 1817)	PM/WM	LC	U	C	S	WC
	Fregatidae							
5	Great Frigatebird	*Fregata minor* (Gmelin, 1789)	SM	LC	U	C	O	AAqC
6	Christmas Island Frigatebird	*Fregata andrewsi* Mathews, 1914	V	CR	U	C	O	AAqC
	Ciconiiformes							
	Ardeidae							
7	Little Egret	*Egretta garzetta* (Linnaeus, 1766)	R/LM	LC	C	C	S	WC
8	Pacific Reef-Egret	*Egretta sacra* (Gmelin,1789)	R	LC	C	C	S	WC
9	Grey Heron	*Ardea cinerea* Linnaeus, 1758	R/WM	LC	R	C	S	WC
10	Purple Heron	*Ardea purpurea* Linnaeus, 1766	R/LM	LC	F	C	S	WC
11	Large Egret	*Casmerodius albus* (Linnaeus,1758)	R/LM	LC	C	C	S	WC
12	Median Egret	*Mesophoyx intermedia* (Wagler,1829)	R/WM	LC	F	C	S	WC
13	Eastern Cattle Egret	*Bubulcus coromandus* (Boddaert, 1783)	R/LM	LC	C	C	G	WC
14	Chinese Egret	*Egretta eulophotes* (Swinhoe, 1860)	WM	LC	R	C	M	WC

Sl. No.	Common Name	Scientific Name	Residential Status	IUCN Status	Abundance Status	Food	Stratum	Behaviour
15	Indian Pond-Heron	*Ardeola grayii* (Sykes,1832)	R/WM	LC	R	C	M	WC
16	Chinese Pond-Heron	*Ardeola bacchus* (Bonaparte, 1855)	WM	LC	F	C	M	WC
17	Andaman Little Green Heron	*Butorides striatus spodiogaster* Sharpe, 1894	R	LC	C	C	M	WC
18	Yellow Bittern	*Ixobrychus sinensis* (Gmelin,1789)	WM	LC	F	C	G	WC
19	Chestnut Bittern	*Ixobrychus cinnamomeus* (Gmelin,1789)	R	LC	F	C	G	WC
20	Black Bittern	*Dupetor flavicollis* (Latham, 1790)	PM/SM	LC	U	C	G	WC
	Pelecaniformes							
	Threskiornithidae							
21	Glossy Ibis	*Plegadis falcinellus* (Linnaeus, 1766)	PM/WM	LC	U	C	G	WC
	Anseriformes							
	Anatidae							
22	Lesser Whistling-Duck	*Dendrocygna javanica* (Horsfield,1821)	R/LM	LC	C	H	F	DH
23	Cotton Teal	*Nettapus coromandelianus* (Gmelin,1789)	R	LC	F	H	F	DH
24	Eurasian Wigeon	*Anas penelope* Linnaeus, 1758	WM	LC	U	H	S	DH
25	Andaman Teal	*Anas gibberifrons* (Muller,1842)	R	LC	F	H	S	DC
26	Garganey	*Anas querquedula* Linnaeus, 1758	WM	LC	R	H	S	DH
27	Ferruginous Pochard	*Aythya nyroca* (Guldenstadt, 1770)	WM	NT	U	H	F	DH
	Gruiformes							
	Rallidae							
28	Andaman Blue-Breasted Rail	*Gallirallus striatus obscurior* (Hume, 1874)	R	NR	F	C	G	WC
29	Corn Crake	*Crex crex* (Linnaeus, 1758)	V	LC	U	C	F	WC
30	Andaman White-breasted Waterhen	*Amaurornis phoenicurus insularis* Sharpe, 1894	R	LC	C	C	G	WC

Sl. No.	Common Name	Scientific Name	Residential Status	IUCN Status	Abundance Status	Food	Stratum	Behaviour
31	Baillon's Crake	*Porzana pusilla* (Pallas, 1776)	WM	LC	R	C	F	WC
32	Ruddy-breasted Crake	*Porzana fusca* (Linnaeus, 1766)	R/WM	LC	R	C	G	WC
33	Watercock	*Gallicrex cinerea* (Gmelin,1789)	R/LM	LC	F	C	G	WC
34	Purple Moorhen	*Porphyrio porphyria* (Linnaeus,1758)	R	LC	C	C	F	WC
35	Common Moorhen	*Gallinula chloropus* (Linnaeus,1758)	R	LC	C	C	F	WC
36	Common Coot	*Fulica atra* Linnaeus,1758	R/LM	LC	R	H	F	DH
	Charadriiformes							
	Jacanidae							
37	Pheasant-tailed Jacana	*Hydrophasianus chirurgus* (Scopoli,1786)	WM	LC	F	H	M	WH
	Charadriidae							
38	Pacific Golden-Plover	*Pluvialis fulva* (Gmelin,1789)	WM	LC	C	C	M	WC
39	Grey plover	*Pluvialis squatarola* (Linnaeus,1758)	WM	LC	R	C	M	WC
40	Little Ringed Plover	*Charadrius dubius* Scopoli,1786	WM	LC	F	C	M	WC
41	Kentish Plover	*Charadrius alexandrines* Linnaeus, 1758	WM	LC	R	C	M	WC
42	Lesser Sand Plover	*Charadrius mongolus* Pallas,1776	WM	LC	C	C	M	WC
43	Greater Sand Plover	*Charadrius leschenaultii* Lesson,1826	WM	LC	F	C	M	WC
44	Grey-headed Lapwing	*Vanellus cinereus* (Linnaeus, 1758)	WM	LC	R	C	M	WC
	Scolopacidae							
45	Pintail Snipe	*Gallinago stenura* (Bonaparte,1830)	WM	LC	C	C	M	WC
46	Common Snipe	*Gallinago gallinago* (Linnaeus, 1758)	WM	LC	F	C	M	WC
47	Jack Snipe	*Lymnocryptes minimus* (Brunnich, 1764)	PM	LC	R	C	F	WC
48	Black-tailed Godwit	*Limosa limosa* (Linnaeus,1758)	WM	NT	R	C	M	WC

Sl. No.	Common Name	Scientific Name	Residential Status	IUCN Status	Abundance Status	Food	Stratum	Behaviour
49	Bar-tailed Godwit	*Limosa lapponica* (Linnaeus,1758)	WM	LC	R	C	M	WC
50	Eurasian Whimbrel	*Numenius phaeopus* (Linnaeus,1758)	WM	LC	C	C	G	WC
51	Eurasian Curlew	*Numenius arquata* (Linnaeus,1758)	WM	NT	C	C	M	WC
52	Spotted Redshank	*Tringa erythropus* (Pallas, 1764)	WM	LC	U	C	M	WC
53	Common Redshank	*Tringa tetanus* (Linnaeus,1758)	WM	LC	C	C	M	WC
54	Marsh Sandpiper	*Tringa stagnatilis* (Bechstein, 1803)	WM	LC	F	C	M	WC
55	Common Greenshank	*Tringa nebularia* (Gunner,1767)	WM	LC	F	C	M	WC
56	Green Sandpiper	*Tringa ochropus* Linnaeus,1758	WM	LC	R	C	M	WC
57	Wood Sandpiper	*Tringa glareola* Linnaeus,1758	WM	LC	F	C	M	WC
58	Terek Sandpiper	*Xenus cinereus* (Guldenstadt,1774)	WM	LC	R	C	M	WC
59	Common Sandpiper	*Actitis hypoleucos* Linnaeus,1758	WM	LC	C	C	M	WC
60	Ruddy Turnstone	*Arenaria interpres* (Linnaeus,1758)	WM	LC	F	C	M	WC
61	Great Knot	*Calidris tenuirostris* (Horsfield, 1821)	WM	VU	R	C	M	WC
62	Little Stint	*Ereunetes minutes* (Leisler,1812)	WM	LC	R	C	M	WC
63	Rufous-necked Stint	*Ereunetes ruficollis* (Pallas, 1776)	WM	LC	F	C	M	WC
64	Temminck's Stint	*Ereunetes temminckii* (Leisler, 1812)	WM	LC	R	C	M	WC
65	Long-toed Stint	*Ereunetes subminutus* (Middendorff, 1853)	WM	LC	F	C	M	WC
66	Curlew Sandpiper	*Erolia ferruginea* (Pontoppidan,1813)	WM	LC	F	C	M	WC
67	Broad-billed Sandpiper	*Limicola falcinellus* (Pontoppidan, 1763)	WM	LC	R	C	M	WC
	Recurvirostridae							WC
68	Black-winged Stilt	*Himantopus himantopus* (Linnaeus, 1758)	WM	LC	R	C	S	WC

Sl. No.	Common Name	Scientific Name	Residential Status	IUCN Status	Abundance Status	Food	Stratum	Behaviour
	Dromadidae							WC
69	Crab-Plover	*Dromas ardeola* Paykull, 1805	R/WM	LC	U	C	M	WC
	Burhinidae							WC
70	Beach Stone- Plover	*Esacus magnirostris* (Vieillot,1818)	R	NT	R	C	M	WC
	Glareolidae							WC
71	Collared Pratincole	*Glareola pratincola* (Linnaeus, 1766)	PM/SM	LC	R	C	M	WC
72	Oriental Pratincole	*Glareola maldivarum* J.R. Forster, 1795	PM/WM	LC	F	C	G	WC
	Laridae							
73	Black headed Gull	*Chroicocephalus ridibundus* Linnaeus, 1766	PM/WM	LC	R	C	A	AAqC
74	Gull-billed Tern	*Gelochelidon nilotica* (Gmelin, 1789)	WM	LC	R	C	A	AAqC
75	Lesser Crested Tern	*Thalasseus bengalensis* Lesson, 1831	WM	LC	F	C	A	AAqC
76	Roseate Tern	*Sterna dougallii* Montagu, 1813	SM	LC	R	C	A	AAqC
77	Black-naped Tern	*Sterna sumatrana* Raffles,1822	R	LC	F	C	A	AAqC
78	Little Tern	*Sternula albifrons* Pallas,1764	WM	LC	R	C	A	AAqC
79	Whiskered Tern	*Chlidonias hybrid* (Pallas, 1811)	WM	LC	F	C	A	AAqC
80	White-Winged Black Tern	*Chlidonias leucopterus* (Temminck, 1815)	PM/WM	LC	F	C	A	AAqC
81	Brown Noddy	*Anous stolidus* (Linnaeus, 1758)	WM	LC	R	C	A	AAqC
	Wetland Dependent and Associated Birds							
	Falconiformes							
	Accipitridae							
82	Brahminy Kite	*Haliastur indus* (Boddaert,1783)	R	LC	F	C	A	ATC
83	White-bellied Sea-Eagle	*Haliaeetus leucogaster* (Gmelin,1788)	R	LC	C	C	A	AAqC
84	Western Marsh-Harrier	*Circus aeruginosus* (Linnaeus, 1758)	WM	LC	U	C	A	ATC

Sl. No.	Common Name	Scientific Name	Residential Status	IUCN Status	Abundance Status	Food	Stratum	Behaviour
85	Japanese Sparrowhawk	*Accipiter gularis* (Temminck & Schlegel, 1845)	WM	LC	U	C	A	ATC
86	BesraSparrowhawk	*Accipiter virgatus* (Temminck & Schlegel, 1845)	SM	LC	R	C	A	ATC
87	Changeable Hawk-Eagle	*Nisaetus cirrhatus andamanensis* Tytler, 1865	R	NR	F	C	L	ATC
	Pandionidae							
88	Western Osprey	*Pandion haliaetus* (Linnaeus, 1758)	V	LC	R	C	A	ATC
	Falconidae							
89	Common Kestrel	*Falco tinnunculus* Linnaeus,1758	WM	LC	F	C	A	ATC
90	Peregrine Falcon	*Falco perigrinuscalidus* Latham, 1790	WM	LC	R	C	A	ATC
	Coraciformes							
	Alcedinidae							
91	Small Blue Kingfisher	*Alcedo atthis* (Linnaeus, 1758)	WM	LC	F	C	A	AAqC
92	Andaman Blue-eared Kingfisher	*Alcedo meninting rufigastra* Walden, 1873	R	LC	R	C	L	ATC
93	Andaman Oriental Dwarf Kingfisher	*Ceyx erithaca macrocarus* Oberholser, 1917	R	LC	R	C	L	ATC
94	Andaman Stork-billed Kingfisher	*Pelargopis capensis osmastoni* (Baker, 1934)	R	LC	C	C	A	AAqC
95	Andaman Ruddy Kingfisher	*Halcyon coromanda mizorhina* (Oberholser, 1915)	R	LC	R	C	L	AAqC
96	Andaman White-breasted Kingfisher	*Halcyon smyrnensis saturatior* Hume, 1874	R	LC	C	C	A	AAqC
97	Black-capped Kingfisher	*Halcyon pileata* (Boddaert, 1783)	WM	LC	F	C	L	AAqC
98	Andaman Collared Kingfisher	*Halcyon chloris davisoni* Sharpe, 1892	R	LC	C	C	L	AAqC
	Meropidae							
99	Blue-tailed Bee-eater	*Merops philippinus* Linnaeus,1766	WM	LC	F	I	A	AI

Sl. No.	Common Name	Scientific Name	Residential Status	IUCN Status	Abundance Status	Food	Stratum	Behaviour
100	Andaman Chestnut headed Bee eater	*Merops leschenaulti andamanensis* Marien, 1950	R		F	I	A	AI
101	Small Bee-eater	*Merops orientalis* Latham, 1801	SM		F	I	A	AI
	Passeriformes							
	Hirundinidae							
102	Sand Martin	*Riparia riparia* (Linnaeus, 1758)	WM	LC	R	I	A	ATC
103	Common Swallow	*Hirundo rustica* Linnaeus,1758	WM	LC	F	I	A	ATC
104	House Swallow	*Hirundo tahitica* Gmelin,1789	R	LC	C	I	A	ATC
105	Red-rumped Swallow	*Hirundo daurica* Linnaeus, 1771	WM	LC	R	I	A	ATC
106	Asian House-Martin	*Delichon dasypus* (Bonaparte, 1850)	SM	LC	R	I	A	ATC
	Motacillidae							
107	White Wagtail	*Motacilla leucopsis* Gould, 1838	WM	LC	R	I	G	SIP
108	EasternYellow Wagtail	*Motacilla tschutschensis* Linnaeus, 1758	WM	LC	F	I	G	SIP
109	Short-tailed Grey-headed Yellow Wagtail	*Motacilla flava thunbergi* Billberg, 1828	WM	LC	F	I	G	SIP
110	Grey Wagtail	*Motacilla cinerea* Tunstall, 1771	WM	LC	F	I	G	SIP
111	Red-throated Pipit	*Anthus cervinus* (Pallas, 1811)	PM	LC	F	I	G	SIP
	Turdidae							
112	Common Stonechat	*Saxicola torquata* (Linnaeus, 1766)	WM	LC	F	I	L	ATC
	Sylviidae							
113	Andaman Palefooted Bush-Warbler	*Urosphena pallidipes osmastoni* (Hartert, 1908)	R	LC	R	I	L	TI
114	Streaked Grasshopper-Warbler	*Locustellalanceolata* (Temminck, 1840)	WM	LC	R	I	L	TI
115	Rusty-rumped Grasshopper-Warbler	*Locustella certhiola* (Pallas, 1811)	WM	LC	R	I	L	TI

Sl. No.	Common Name	Scientific Name	Residential Status	IUCN Status	Abundance Status	Food	Stratum	Behaviour
116	Black-browed Reed-Warbler	*Acrocephalus bistrigiceps* Swinhoe, 1860	WM	LC	F	I	L	TI
117	Oriental Great Reed-Warbler	*Acrocephalus orientalis* (Temminck & Schlegel, 1847)	WM	NR	F	I	L	TI
118	Indian Great Reed-Warbler	*Acrocephalus stentoreus*(Hemprich& Ehrenberg, 1833)	WM	LC	F	I	L	TI
119	Eastern Thick-billed Warbler	*Acrocephalus aedon* (Pallas, 1776)	WM	LC	R	I	L	TI
120	Dusky Warbler	*Phylloscopus fuscatus* (Blyth, 1842)	WM	LC	F	I	L	TI
	Muscicapidae							
121	Red-throated Flycatcher	*Ficedula parva* (Bechstein, 1792)	WM	LC	F	I	G	TI
	Pachycephalidae							
122	Mangrove Whistler	*Pachycephala grisola* (Blyth,1843)	R	LC	F	C	L	AAqC

Table 3: Distribution of wetland birds in the tsunami inundated wetlands of South Andaman

Sl. No.	Common Name	Garacharma	Sippighat	Chouldari	Ograbraj	Stewartgunj	Chidyatappu	Shoal Bay
1	Little Grebe		√				√	
2	Wedge-tailed Shearwater						√	
3	Red-footed Booby	√						
4	Little Cormorant				√			
5	Great Frigatebird				√			
6	Christmas Island Frigatebird				√			
7	Little Egret	√	√	√	√	√	√	√
8	Pacific Reef-Egret	√	√	√	√	√	√	√
9	Grey Heron	√	√	√	√	√		
10	Purple Heron	√	√	√	√	√		
11	Large Egret	√	√	√	√	√	√	√
12	Median Egret	√	√	√	√	√	√	√
13	Eastern Cattle Egret	√	√	√	√	√	√	√
14	Chinese Egret		√		√		√	

Sl. No.	Common Name	Garacharma	Sippighat	Chouldari	Ograbraj	Stewartgunj	Chidyatappu	Shoal Bay
15	Indian Pond-Heron	√	√	√	√	√	√	√
16	Chinese Pond-Heron	√	√	√	√	√	√	√
17	Andaman Little Green Heron	√	√	√	√	√	√	√
18	Yellow Bittern	√	√	√	√	√	√	√
19	Chestnut Bittern	√	√	√	√	√	√	√
20	Black Bittern		√	√	√			
21	Glossy Ibis	√		√				
22	Lesser Whistling-Duck	√	√	√	√	√	√	√
23	Cotton Teal	√	√	√	√	√	√	
24	Eurasian Wigeon	√	√		√			
25	Andaman Teal	√	√	√	√	√	√	√
26	Garganey		√		√		√	
27	Ferruginous Pochard		√					
28	Andaman Blue-Breasted Rail	√	√	√	√	√	√	√
29	Corn Crake		√					
30	Andaman White-breasted Waterhen	√	√	√	√	√	√	√
31	Baillon's Crake	√	√	√				
32	Ruddy-breasted Crake	√	√	√	√	√	√	
33	Watercock	√	√	√	√	√	√	√
34	Purple Moorhen	√	√	√	√	√	√	√
35	Common Moorhen	√	√	√	√	√	√	√
36	Common Coot		√	√	√	√		
37	Pheasant-tailed Jacana	√	√	√	√	√		
38	Pacific Golden-Plover	√	√	√	√	√	√	√
39	Grey plover	√	√	√	√			
40	Little Ringed Plover	√	√	√	√	√		√
41	Kentish Plover	√	√		√	√		√
42	Lesser Sand Plover	√	√	√	√	√	√	√
43	Greater Sand Plover	√	√	√	√	√	√	√
44	Grey-headed Lapwing	√	√	√	√	√		√
45	Pintail Snipe	√	√	√	√	√	√	√
46	Common Snipe	√	√	√	√			
47	Jack Snipe				√			
48	Black-tailed Godwit	√	√	√	√			

Sl. No.	Common Name	Garacharma	Sippighat	Chouldari	Ograbraj	Stewartgunj	Chidyatappu	Shoal Bay
49	Bar-tailed Godwit	√	√		√			
50	Eurasian Whimbrel	√	√	√	√	√	√	√
51	Eurasian Curlew	√	√	√	√	√	√	
52	Spotted Redshank	√	√					
53	Common Redshank	√	√	√	√	√	√	√
54	Marsh Sandpiper	√	√	√	√			
55	Common Greenshank	√	√	√	√	√		
56	Green Sandpiper			√	√	√		
57	Wood Sandpiper	√	√	√	√	√	√	√
58	Terek Sandpiper	√	√	√				
59	Common Sandpiper	√	√	√	√	√	√	√
60	Ruddy Turnstone	√	√		√			
61	Great Knot	√	√					
62	Little Stint	√	√		√			
63	Rufous-necked Stint	√	√	√	√	√	√	√
64	Temminck’s Stint	√	√		√			
65	Long-toed Stint	√	√	√	√	√	√	√
66	Curlew Sandpiper	√	√	√	√	√	√	√
67	Broad-billed Sandpiper	√	√	√	√			
68	Black-winged Stilt			√	√			
69	Crab-Plover							√
70	Beach Stone- Plover						√	√
71	Collared Pratincole	√	√					
72	Oriental Pratincole	√	√	√	√	√	√	√
73	Black headed Gull	√			√			
74	Gull-billed Tern				√			
75	Lesser Crested Tern	√		√	√			
76	Roseate Tern	√	√				√	
77	Black-naped Tern	√	√	√	√	√	√	√
78	Little Tern	√						
79	Whiskered Tern	√	√	√	√			
80	White-Winged Black Tern	√	√	√	√			
81	Brown Noddy						√	
82	Brahminy Kite	√	√	√	√	√	√	√

Sl. No.	Common Name	Garacharma	Sippighat	Chouldari	Ograbraj	Stewartgunj	Chidyatappu	Shoal Bay
83	White-bellied Sea-Eagle	√	√	√	√	√	√	√
84	Western Marsh-Harrier	√	√	√	√			
85	Japanese Sparrowhawk	√					√	
86	BesraSparrowhawk	√	√	√		√	√	
87	Changeable Hawk-Eagle	√	√	√	√	√	√	√
88	Western Osprey		√					√
89	Common Kestrel	√	√	√	√	√	√	
90	Peregrine Falcon				√	√		
91	Small Blue Kingfisher	√	√	√	√	√	√	√
92	Andaman Blue-eared Kingfisher	√	√	√		√	√	√
93	Andaman Oriental Dwarf Kingfisher	√	√				√	√
94	Andaman Stork-billed Kingfisher	√	√	√	√	√	√	√
95	Andaman Ruddy Kingfisher	√	√	√	√		√	√
96	Andaman White-breasted Kingfisher	√	√	√	√	√	√	√
97	Black-capped Kingfisher	√	√			√	√	
98	Andaman Collared Kingfisher	√	√	√	√	√	√	√
99	Blue-tailed Bee-eater	√	√	√	√	√	√	√
100	Andaman Chestnut-headed Bee-eater	√	√	√	√	√	√	√
101	Small Bee-eater	√	√	√	√	√	√	√
102	Sand Martin				√			
103	Common Swallow	√	√	√	√	√	√	√
104	House Swallow	√	√	√	√	√	√	√
105	Red-rumped Swallow	√	√	√	√			
106	Asian House-Martin				√			
107	White Wagtail	√						
108	Eastern Yellow Wagtail	√	√	√	√	√	√	√
109	Short-tailed Grey-headed Yellow Wagtail	√	√	√	√	√	√	√
110	Grey Wagtail	√	√	√	√	√	√	√
111	Red-throated Pipit	√	√				√	√
112	Common Stonechat	√	√	√	√		√	√

Sl. No.	Common Name	Garacharma	Sippighat	Chouldari	Ograbraj	Stewartgunj	Chidyatappu	Shoal Bay
113	Andaman Pale-footed Bush-Warbler		√			√	√	√
114	Streaked Grasshopper-Warbler				√		√	
115	Rusty-rumped Grasshopper- Warbler				√			
116	Black-browed Reed-Warbler		√		√		√	
117	Oriental Great Reed-Warbler	√	√	√	√	√		
118	Indian Great Reed-Warbler	√	√	√	√	√		
119	Eastern Thick-billed Warbler						√	
120	Dusky Warbler	√	√	√	√	√	√	√
121	Red-throated Flycatcher	√	√	√	√	√	√	√
122	Mangrove Whistler	√	√	√		√	√	√

Table 4: Shorebirds recorded from the tsunami inundated wetlands

Sl. No.	Common Name	Garacharma	Sippighat	Chouldari	Ograbraj	Stewartgunj	Chidyatappu	Shoal Bay
1	Pheasant-tailed Jacana	√	√	√	√	√		
2	Pacific Golden-Plover	√	√	√	√	√	√	√
3	Grey plover	√	√	√	√			
4	Little Ringed Plover	√	√	√	√	√		√
5	Kentish Plover	√	√		√	√		√
6	Lesser Sand Plover	√	√	√	√	√	√	√
7	Greater Sand Plover	√	√	√	√	√	√	√
8	Grey-headed Lapwing	√	√	√	√	√		√
9	Pintail Snipe	√	√	√	√	√	√	√
10	Common Snipe	√	√	√	√			
11	Jack Snipe				√			
12	Black-tailed Godwit	√	√	√	√			
13	Bar-tailed Godwit	√	√		√			
14	Eurasian Whimbrel	√	√	√	√	√	√	√

Sl. No.	Common Name	Garacharma	Sippighat	Chouldari	Ograbraj	Stewartgunj	Chidyatappu	Shoal Bay
15	Eurasian Curlew	√	√	√	√	√	√	
16	Spotted Redshank	√	√					
17	Common Redshank	√	√	√	√	√	√	√
18	Marsh Sandpiper	√	√	√	√			
19	Common Greenshank	√	√	√	√	√		
20	Green Sandpiper			√	√	√		
21	Wood Sandpiper	√	√	√	√	√	√	√
22	Terek Sandpiper	√	√	√				
23	Common Sandpiper	√	√	√	√	√	√	√
24	Ruddy Turnstone	√	√		√			
25	Great Knot	√	√					
26	Little Stint	√	√		√			
27	Rufous-necked Stint	√	√	√	√	√	√	√
28	Temminck's Stint	√	√		√			
29	Long-toed Stint	√	√	√	√	√	√	√
30	Curlew Sandpiper	√	√	√	√	√	√	√
31	Broad-billed Sandpiper	√	√	√	√			
32	Black-winged Stilt			√	√			√
33	Crab-Plover		√					
34	Beach Stone- Plover						√	√
35	Collared Pratincole	√	√					
36	Oriental Pratincole	√	√	√	√	√	√	√

Arrival and departure of migratory birds

The migratory birds arrived in the tsunami inundated wetlands in the month of September onwards during the three migratory seasons. Arrival and departure of resident and migratory birds for the period of three years is presented in Table 5. Eighty-nine species of migratory birds were observed, of these, sixty-nine species were winter migrants. The result shows that, most of the migratory birds are arriving during the month of August/ September and stay upto March/April in Andaman Islands. The departure of migratory birds started in early March, and continued up to May, however few species were recorded in all months during the study period.

Table 5: Arrival and Departure of resident and migratory birds

Common Name	2013-2014		2014-2015		2015-2016	
	Arrival	Departure	Arrival	Departure	Arrival	Departure
Little Grebe			11th February	13th May		
Wedge-tailed Shearwater			19th May	28th May		
Red-footed Booby			30th December	14th June		
Chinese Egret				17th March	22nd January	12th April
Yellow Bittern	5th November	27th May	7th November	6th June	7th October	25th May
Eurasian Wigeon	19th November	2nd April				
Garganey	18th December	29th April	19th November	13th April	12th November	26th April
Ferruginous Pochard			17th December	3rd January	12th November	
Western Marsh-Harrier	7th November	10th January	21st January	24th April	12th November	15th February
Western Osprey			19th April	14th May	14th February	16th May
Common Kestrel	15th November	11th February	8th December		15th November	
Peregrine Falcon	12th January	13th March			18th November	
Baillon's Crake	24th December	5th May	8th January	14th April	9th February	
Common Coot	18th April	5th February	14th September	26th February	6th June	
Pheasant-tailed Jacana	18th September	5th April	12th August	13th April	12th December	
Pacific Golden-Plover	20th August	27th July	1st July	6th May	8th July	14th May
Grey plover	2nd August	24th September	6th November	25th April	7th October	
Little Ringed Plover	24th September	8th April	28th October	2nd April	19th September	
Kentish Plover	9th February	26th March	19th February	27th March	19th November	03rd May
Lesser Sand Plover	8th May				7th October	12th April
Greater Sand Plover	6th August	5th May	7th July	6th May	15th July	15th May
Grey-headed Lapwing	24th September	8th March	19th November	14th February	9th October	29th April
Pintail Snipe	14th August	29th April	26th September	22nd April	19th September	
Common Snipe	14th August	11th March	10th September	12th March	27th November	25th May
Jack Snipe	14th October	27th March	27th January	11th March		24th January
Black-tailed Godwit	12th November	13th May	24th September	2nd April	12th November	
Whimbrel	30th May				7th October	
Eurasian Curlew	23rd April				7th October	15th February

Common Name	2013-2014		2014-2015		2015-2016	
	Arrival	Departure	Arrival	Departure	Arrival	Departure
Spotted Redshank			19th September		7th October	
Common Redshank	24th April		2015		7th October	
Marsh Sandpiper	18th December	2nd April	9th October	13th May	18th July	16th May
Common Greenshank	6th August	29th April	11th September	2nd April	7th October	
Green Sandpiper	5th November	2nd February	15th October	18th December	16th December	
Wood Sandpiper	20th August	13th May	10th July	22nd April	12th August	12th March
Terek Sandpiper	12th July	19th March	11th September	26th November	19th September	
Common Sandpiper	6th August	5th May	10th July	13th May	12th August	03rd May
Ruddy Turnstone	6th August	27th March	24th September	22nd March	8th October	12th April
Great Knot	24th December	10th March	14th January	27th March	15th December	15th May
Little Stint	6th August	27th March	20th August	4th February	19th November	29th April
Rufous-necked Stint	4th December	22nd April	20th August	19th May	8th July	
Temminck's Stint			15th October	12th December	8th July	25th May
Long-toed Stint	19th November	29th April	12th August	13th May	8th July	24th January
Curlew Sandpiper	6th August		2015		8th July	
Broad-billed Sandpiper	24th November	15th March	7th December	23rd January	2nd December	26th April
Black-winged Stilt			7th November	22nd March	15th December	
Gull-billed Tern					10th April	
Lesser Crested Tern	24th September	110th January	7th November	14th January	24th November	
Little Tern	12th July	12th November	12th August	9th October	12th September	3rd May
Whiskered Tern			17th October	30th November	2nd October	12th April
Brown Noddy			29th June			29th April
Small Blue Kingfisher	21st March	12th April	12th October	27th April	11th May	
Black-capped Kingfisher	20th October		20th October		15th October	25th May
Blue-tailed Bee-eater	18th September	27th March	24th September	4th February	2nd October	24th January
Sand Martin						26th April
Common Swallow	18th August	22nd April	9th October	14th April	12th August	
Red-rumped Swallow	17th December	23rd March	23rd December	27th February	12th December	15th February
Yellow Wagtail	5th September	29th April	11th September	22nd April	25th September	

Common Name	2013-2014		2014-2015		2015-2016	
	Arrival	Departure	Arrival	Departure	Arrival	Departure
Short-tailed Grey-headed Yellow Wagtail	5th September	29th April	11th September	22nd April	25th September	16th May
White Wagtail	18th November	28th January	6th December	18th February	12th December	
Grey Wagtail	24th September	20th January	6th September	21st February	10th September	
Common Stonechat	6th December	8th February	4th November	14th April		
Streaked Grasshopper-Warbler					12th January	17th April
Rusty-rumped Grasshopper- Warbler					4th January	11th April
Black-browed Reed-Warbler			6th November	18th January	18th December	03rd May
Oriental Great Reed-Warbler	17th December	21st February	8th January	20th March	19th November	12th April
Indian Great Reed-Warbler	29th November	2nd April	7th November	22nd April	28th January	15th May
Eastern Thick-billed Warbler			7th March	10th April		29th April
Dusky Warbler	12th November	13th May	28th October	12th March	3rd November	
Red-throated Flycatcher	14th October	27th March	9th October	27th January	13th December	25th May
Bar-tailed Godwit	1st October	27th March	24th September	12th March	2nd October	26th April
Greater Short-toed Lark	15th December				19th December	
Red-throated Pipit	29th November	26th January	6th December	4th February	19th December	12th March
Black Bittern			14th January	12th March		
Collared Pratincole			27th March	14th April	12th January	
Little Cormorant			14th March	22nd April		
Glossy Ibis		18th September	14th April	12th March	17th January	24th January
Oriental Pratincole	5th November	5th May	7th November	22nd April	12th November	
Black headed Gull			9th March		12th January	16th May
White-Winged Black Tern	25th January	2nd March	25th March	14th May		15th May
Chinese Pond-Heron	18th September	13th April	9th October	15th April	7th October	29th April
BesraSparrowhawk	27th November	14th January	24th September	16th January	12th November	

Common Name	2013-2014		2014-2015		2015-2016	
	Arrival	Departure	Arrival	Departure	Arrival	Departure
Grey Heron	4th December	10th April	9th October	22nd April	19th September	03rd May
Indian Pond-Heron	14th October	13th May	9th October	19th May	6th October	15th May
Crab-Plover					12th January	15th February
Great Frigatebird			14th March	18th March		
Roseate Tern			10th May		18th June	12th March
Asian House-Martin					24th November	
Christmas Island Frigatebird			11th June	7th July		
Corn Crake					9th February	12th March

Comparative occurrence of wetland birds

A comparison of number of wetland bird species recorded from the tsunami inundated wetlands with those from Andaman & Nicobar Islands, India, Asia and World is given in Table 6. Out of the 245 species of wetland birds recorded from India, 50 percent were found in the tsunami inundated wetlands.

Table 6: Comparative occurrence of wetland bird species in the tsunami inundated wetlands

Order and Family	World[1]	Asia[1]	India[2]	A & N Islands[3]	South Andaman *
Podicipediformes					
Podicipedidae	25	6	5	1	1
Procellariiformes					
Procellariidae	110	33	9	1	1
Pelecaniformes					
Sulidae	13	5	3	1	1
Fregatidae	5	3	3	3	2
Threskiornithidae	39	14	4	1	1
Phalacrocoracidae	40	13	3	1	1
Ciconiiformes					
Ardeidae	82	33	20	18	14
Anseriformes					
Anatidae	192	81	41	10	6
Gruiformes					
Rallidae	190	45	18	14	9
Charadriiformes					
Jacanidae	8	3	2	1	1
Charadriidae	75	32	19	8	7
Scolopacidae	102	72	42	28	23
Recurvirostridae	13	2	2	1	1
Dromadidae	1	1	1	1	1
Burhinidae	11	5	4	1	1
Glareolidae	18	9	6	2	2
Laridae	120	65	37	15	9
Falconiformes					
Accipitridae	295	102	59	27	6
Falconidae	70	28	13	5	2
Pandionidae	3	1	1	1	1
Apodiformes					
Apodidae	123	34	16	7	1
Coraciformes					
Alcedinidae	142	59	12	11	8

Meropidae	35	11	6	3	1
Passeriformes					
Hirundinidae	102	24	16	5	5
Motacillidae	34	27	21	9	5
Turdidae	198	73	28	11	1
Sylviidae	342	154	18	16	8
Muscicapidae	323	171	102	5	1

1 - Gill and Donsker (2012); 2 - Ali and Ripley (1983); 3 - Tikader, 1984; 4 - Present study

Discussion

The number of species recorded from the tsunami inundated wetlands of south Andaman showed high species richness, which is comparable to other wetlands in India. In the present study, 122 species of wetland and wetland dependent birds were recorded, which showed the importance of the area as a wintering ground for migratory species. The highest species of birds were recorded from Sippighat, followed by Ograbraj, Garacharma, Chouldhari, Chidiyatappu, Stewartgunj and Shoal Bay. In the present study, 38 species of trans-continental migrants were recorded, which showed the importance of the area as a wintering ground for migratory species.

The migratory birds arrived in the tsunami inundated wetlands in the month of September onwards during the three migratory seasons. Eighty nine species of migratory birds were observed, of these, sixty nine species were winter migrants. The result shows that, most of the migratory birds are arriving during the month of August/ September and stay upto March/April in Andaman Islands. The departure of migratory birds started in early March, and continued upto May, however few species were recorded in all months during the study period.

Among the trans-continental migrants, Bar-tailed Godwit, Great Knot and Whimbrel are apparently capable of long distance flights (Driscoll and Ueta, 2000).Of the recorded species, seventy species were winter migrant, 24 species were resident. According to IUCN redlist, 114 species were listed as Least Concern in the IUCN red list, four species are Near Threatened, one species Vulnerable and three species are not recognized. The sighting of Chinese Egret from the Andaman Islands was the first record of the species from India and South Asia.

Also the reports of nineteen new records from this islands shows the importance of the conservation of wetlands *i.e.* Marsh Sandpiper *Tringa stagnatilis,* Black-tailed Godwit *Limosa limosa,* Pheasant-tailed jacana *hydrophasianus chirugus,* Glossy Ibis *Plegadis falcinellus,* **Black-winged Stilt** *Himantopus himantopus,* **Black-headed Gull***Chroicocephalus ridibundus,* Chinese Egret *Egretta eulophotes,* Ruff *Philomachus pugnax,*Heuglin's Gull *Larus fuscus,* Grey-headed Lapwing *Vanellus cinereus,* Corn Crake *Crex crex,* Ferruginous Pochard *Aythra Nyroca,* Garganey *Anas querquedula,Wedge-tailed ShearwaterPuffinuspacificus,* Eurasian Wigeon *Anas Penelope,*Collared Pratincole *Glareola pratincola,* Little Cormorant *Phalacrocorax niger,*Common Starling *Sturnus vulgarius,* andPied Crested Cuckoo *Clamator jacobinus.* As this wetland is coming under '*East-Asian Australasian Flyway*', protection of the migratory species is of highest priority. The wetlands of Andaman are an ideal habitat for migratory and resident birds, especially for the winter visitors.

Acknowldgements

The authors would like to thanks Dr. Kailash Chandra, Director, Zoological Survey of India, Kolkata for providing necessary support. We thank Department of Science & Technology, Ministry of Science & Technology, Government of India for financial support through DST-SERB Fast Tract Young Scientist Schmene.

References

Adams, G.D. (1988). "Wetlands of the Prairies of Canada" in Wetlands of Canada. National Wetlands Working Group Ecological Land Classification Series, No.

24. Sustainable Development Branch, Environment Canada, Ottawa, Ontario, and Polyscience Publications Inc., Montreal, Quebec. 452p.

Ali, S. & Ripley, S.D. (1983). Hand Book of the Birds of India and Pakistan. Oxford University Press, Oxford. 737 p.

BirdLife International, (2004). *Threatened birds of the world. 2004*. Cambridge: BirdLife International.

BirdLife International, (2019). The BirdLife checklist of the birds of the world:. Downloaded from http://www.birdlife.org/ datazone/userfiles/ file/Species/ Taxonomy/ BirdLife_Checklist_ Version _80.

Clements, J.F. (2007). The Clements checklist of the birds of the world. New York: Cornell University Press.

Dam Roy, S., Krishnan, P., Shesdev Patro, Grinson George, Velmurugan, A., Kiruba Sankar, R. & Ramachandran, P. (2017). Wetlands of Small Island Nations in South Asia vis-ą-vis the Mainland and Island Groups in India: Status and Conservation Strategies. In: Prusty, A.K., Chandra, R. and Azeez, P.A. (Eds.). Wetland Science: Perspectives from South Asia. Springer Nature, India. pp. 31-50.

Finlayson, C.M., & Spiers, A.G. (Eds.). (1999). Global Review of Wetland Resources and Priorities for Wetland Inventory. Supervising Scientist, Canberra, Australia.

Ghermandi, A., van den Bergh, J.C.J.M., Brander, L.M., & Nunes, P.A.L.D. (2008). The Economic Value of Wetland Conservation and Creation: A Meta-Analysis. [Working Paper 79]. Fondazione Eni Enrico Mattei, Milan, Italy.

Gill, Jr, Robert, Piersma, T., Hufford, G., Servranckx, R. & Riegen, A. (2009). Crossing the ultimate ecological barrier: Evidence for an 11000-km-long nonstop flight from Alaska to New Zealand and eastern Australia by Bar-tailed Godwits. The Condor. 107. 1-20.

Holmes, V.R., Cable, T.T.& Brack,V.J.K. (1986). Avifauna as indicators of North Indiana. *Indian Academy of Science, (Zool.)* **95**: 523-528.

IUCN, (2009). International Union for Conservation of Nature and Natural Resources Red List. 2009. www.iucnredlist.org/

Jin-Han Im, Byund-Ho Yoo, Changman Won, Jin-Young Park &Jeong-Yeon Yi. (2001). An agricultural habitat indicator for wildlife, OECD Expert meeting on Agri-Biodiversity Indicator, November 2001, Switzerland. 12

Johnson, T.H. & Stattersfield, A.J. (1990). A global review of island endemic birds. *Ibis,* 132: 167-180.

Lehner, B., & Doll, P. (2004). Development and validation of a global database of lakes, reservoirs and wetlands. J. Hydrol. 296(1-4), 1-22.

Martin, T.E. & Blackburn, G.A. (2010). Impacts of Tropical Forest Disturbance Upon Avifauna on a Small Island with High Endemism: Implications for Conservation. Conservat Soc., **8**:127-39.

MEA(Millennium Ecosystem Assessment) (2005). Ecosystems and human well-being : synthesis (PDF). *Washington, DC: Island Press.*Retrieved 7 August 2014.

Pimm, S.L., Russell, G.A., Gittleman, J.L. & Brooks, T.M. (1995). The Futhre of Biodiversity. Science 269: 347-350.

Prasad, S.N., Ramachandra, T.V., Ahalya, N., Sengupta, T., Kumar, A., Tiwari, A.K., Vijayan, V.S., & Vijayan, L. (2002). Conservation of wetlands of India - a review. Trop. Ecol. 43 (1), 173-186.

Space Applications Centre, (2011). National Wetland Atlas, SAC/EPSA/ABHG/NWIA/ATLAS/34/*2011, Space Applications Centre* (ISRO), Ahmedabad, India, 310p.

ten Brink, P., Bassi, S., Badura, T., Hart, K., & Pieterse, M. (2012b). Incentive Measures and Biodiversity – A Rapid Review and Guidance Development - Volume 3: Guidance to identify and address incentives which are harmful to biodiversity A report to Defr.

Tikader, B.K. (1984). Birds of Andaman & Nicobar Islands. Calcutta: Zoological Survey of India.

Trevino, H.S., Skibiel, A.L., Karels, T.J. & Dobson, K.F. (2007). Threats to avifauna on oceanic islands. *Conservation Biology* ,21: 125-132.

Turner, J.R., Vousden, D., Klaus, R., Satyanarayana, C., Fenner, D., Venkataraman,K., Rajan, P.T. & Rao, N.V.S. (2001). Remote sensing and rapid site assessment survey. Report of phase 1: April 2001. GOI / UNDP GEF. Coral reef ecosystems of the Andaman Islands.

Received : 6th February 2020 Accepted : 4th May 2020

Distribution of Intertidal Molluscs (Gastropoda, Bivalvia) from selected sites of North Andaman Island, India

S. Rajendra* and C. Sivaperuman

Andaman and Nicobar Regional Centre, Zoological Survey of India, Port Blair – 744 102. Andaman and Nicobar Islands

Corresponding author: rajenzsi1992@gmail.com

Abstract

Molluscs are benthic macro invertebrates and play an important role in the intertidal ecosystem. The present study aimed to assess the distribution of Molluscan fauna in the intertidal regions of North Andaman Island. The intertidal habitat of the study areas mainly composed of rocky, sandy and muddy regions. In this study, we have collected both live and dead shells from all study sites, and 102 species of gastropods and 17 species of bivalves were recorded. Gastropods are commonly occurring in various substrates such as beneath rocks, muddy, sandy, whereas most of bivalves found at soft substratum and as burrowers on coral and rocks. Among seven study sites, the species richness was highest in Kalipur (82 species), followed by Ram Nagar (20 species). High similarity was observed between Durgapur and Ross Island (74%) and lowest between Ram Nagar and Aerial Bay (28%). A total 89 species were recorded at rocky substratum followed by 58 species in sandy and only 20 species found at muddy substratum. Habitat heterogeneity, geographical distance, physiochemical factors and ecological communities could characterize species composition and distribution among intertidal study areas.

Keywords: Andaman, Benthic invertebrates, habitat, Sea shells, species composition

Introduction

Molluscs are diverse group and second largest phyla after arthropoda in invertebrates including the class Gastropoda, Bivalvia, Aplacophora, Polyplacophora, Scaphopoda and Cephalopoda (Wong and Arshad, 2011; WoRMS, 2020). They are ecologically adapted to any typical environments such as marine (intertidal to deepest ocean), freshwater and land (low to high altitude regions) (Ellen *et al.,* 2008; Rosenberg, 2014). Molluscs constitutes of an important component in marine biodiversity and recorded from various diverse habitats of Andaman and Nicobar Islands (Subba Rao, 2003). They play potential role in ecological sustainability as well as pharmaceutical and economic perceptions. They are extensively important faunal communities in benthic ecosystem through functions related to degradation of organic detritus as they consume living and decaying algae and plant material (Darwin and Padmavati, 2017). These animals acts as pollution level indicators and balancing ecosystem and considered as bioindicator of coastal and marine habitat.

The intertidal zone is one of the most important regions and provides a habitat for benthic micro, macrofauna of marine biota (Raghunathan *et al.,* 2003). Seashells are much diversified biota from the intertidal zone (rocky, sandy, muddy and mangrove areas) to the sub tidal region of these islands and recorded even from 3000 meters depth in Andaman Sea (Dey, 2016). The highest high tide and lowest low tide plays an important role in community structure and composition of intertidal benthic organisms (Molles, 2013). Rocky shore organisms are facing intense physiochemical conditions during tidal changes from upper to lower intertidal zones (Baharuddin *et al.*, 2018). Among the intertidal marine diversity, molluscs are one of the dominated animal group and successfully adapted to diel changes in dessication, exposure and submergence animal phyla. Studies on molluscs fauna (gastropoda and bivalvia) well known from these Islands (Rajagopal and Daniel, 1973; Daniel and Rajagopal, 1974; Subba Rao and Dey, 1991 and 2000; Ansari *et al.* 2006; Franklin *et al.*, 2013 and 2014; Apte, 2014) among them most of studies were focused on species taxonomic description or functional groups.

The studies on distribution and species composition of intertidal molluscs in the north Andaman Islands were scarce. Recently Jeeva *et al.* (2018) studied distribution of gastropods in the intertidal environments of South, Middle and North Andaman Islands. However, there is virtually no information available on the status of molluscan fauna along the north Andaman Coast. Therefore, the present study focused on species composition of molluscan fauna in the intertidal habitat especially gastropoda and bivalvia.

Study area

Andaman and Nicobar Islands are a group of 572 islands, islets and rocky outcrops located geographically North to South between 6°45’ - 13°40’ N latitudes and 92°12’ - 93°55’ E longitudes extend over 800 km, and coastline covers over 1,962 km. The Andaman Islands (10°30′ - 14º; 92º-93º) are emerged is a part of a mountain chain and lie on a ridge, which extends southward from the Irrawaddy delta area of Burma (Tikader *et al.,* 1986). At many places, rocky, sandy and muddy beaches occur between mangroves and coral reefs in the littoral region. The Andaman Sea surrounded by Burma, Thailand, Malaysia on the East and Andaman and Nicobar Islands on the West. The northern most part of the Andaman Archipelago comprises of pristine mangrove and serene beaches (Venkataraman *et al.*, 2003; http://www.andamans.gov.in). In the present study, intensive survey was carried out in the intertidal regions of seven locations along the North Andaman Islands during 2017 to 2019 (Table 1 and Fig. 1).

Table 1: Details of intertidal study areas of North Andaman Island

Study area	GPS cordinates		Habitat description
	Latitude(N)	Longitude (E)	
Aerial Bay	13°16.900′	93°02.583′	Majority muddy habitat and low rocky exposed area. Low and narrow ranges of intertidal exposure. Mangrove patches at upper intertidal region. The water habitat always turbid due to discharge of wastewater runoff.
Durgapur	13°16.350′	93°02.583′	Long intertidal region and wider endowed with rocky area and very less sandy beach. Low tide exposed with dead corals. Rocks and dead corals area covered with algae and rock pools are common.
Kalipur	13°13.516′	93°02.966′	Intertidal exposure is long and constitutes of rocky exposure area one side and sandy substratum on other side. Muddy region (mangroves and their associates) observed at upper intertidal region.
Lamiya Bay	13°12.116′	93°02.383′	Intertidal constitute of rocky area very narrow and long stretch in that region.
Brush Island	13°17.716′	93°02.95′	It is a small Island, one side rocky other side sandy substrates.
Ross Island	13°18.066′	93°04.266′	Island connected with Smith Island by sand bar. Intertidal area exposed small rocks, flat rocks and intertidal pools are present.
Ram Nagar	13°04.345'	93°01.562'	Soft sand and freshwater runoff at right side. Low intertidal exposure.

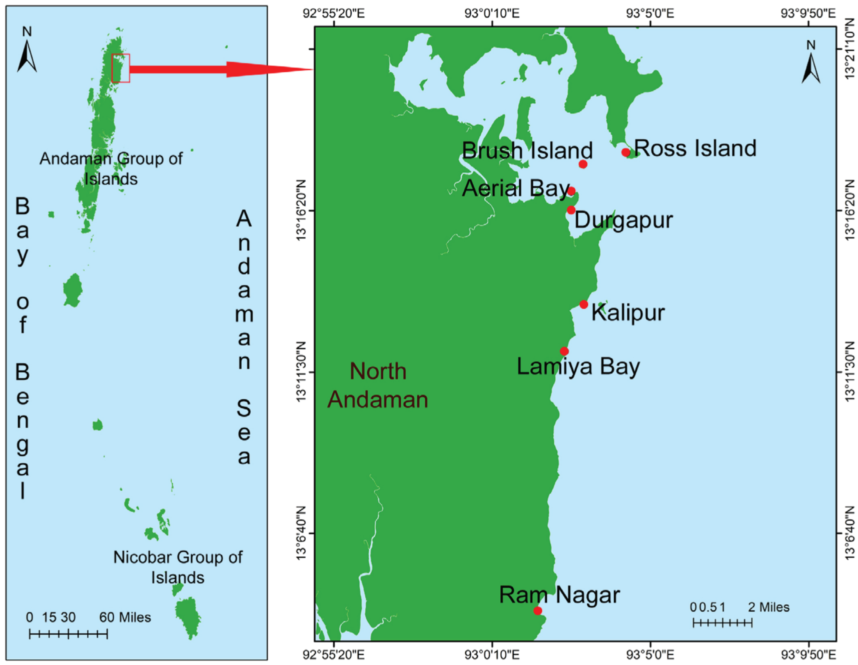


Fig. 1. Map showing study areas of North Andaman group of Islands

Methods

The molluscs were collected from the intertidal areas, besides the rocks and crevices were also searched for molluscs specimens, sometimes rocks were hand lifted or upturned (Underwood and Chapman, 1996). Samplings were carried at lowest low tide covered whole areas wherever possible. Maximum effort taken to identify the species in the field, doubtful samples were collected for identification in the laboratory. Collected materials were brought to the laboratory and rinsed, adhering debris removed. Later, species were sorted out, and dried shells processed for identification up to lowest possible taxon following standard available literature (Abbott and Dance, 1990; Subba Rao, 2000 and 2003; Ramakrishna and Dey, 2003, 2010; Anbalagan and Samuel, 2012).

Distribution ranges (D) of molluscs were calculated by equation (Ahmadreza *et al.*, 2012) (Table 2). D = n/N*100 (n= Presence of individual in number of stations; N=Total number of stations)

Table 2: Calculation of mollusc species ranges

D (%)	0-19.99%	20-39.99%	40-59.99%	60-79.99%	80-100%
Rarity	Very rare	Rare	Relatively common	Common	Very common

Species similarity among stations were calculated by using PAST software (version 1.83) (Sørensen, 1948).

Results

During the study period, we have recorded 119 species of molluscs (Gastropod and Bivalves). Of which, 102 species of gastropods belonging to 66 genera, 32 families and 7 orders, and 17 species of Bivalves belonging to 14 genera, 11 families and 6 orders were identified in this study (Table 4; Plate 1-4). The order Neogastropoda showed highest species richness (40 species) followed by Littorinimorpha (32 species), Trochida and Caenogastropoda (11 species each), Cardida (six species), Osteridae, Cycloneritidae and Venerida (four species each) Cepahlaspidea (two species) and the orders Lepitellida, Ellobida, Arcida, Pectinida, Lucinida and Adapendonta (one species each) (Fig. 2).

Among the Gastropoda, the family Cypraeidae showed more number of species (15 species) followed by Conidae (10 species), Strombidae (eight species), Turbinidae (seven species), Muricidae and Pachychilidae (six species each), Naticidae (five species), Neritidae, Nassaridae, Fasciolariidae, and Olividae represented four species each. The family Mitridae (three species), Tegulidae, Potamididae, Cerithidae, Pisaniidae, Cerithidae, Terebridae recorded two species each. The remaining families such as, Lottidae, Haliotidae, Trochidae, Angaridae, Planaxidae, Seraphsidae, Cassididae, Tonnide, Bursidae, Turbinellidae, Harpidae, Clavatulidae, Bullidae, Hamaenoidae recorded one species each (Fig. 3). The families of Bivalvia, Veneridae and Cardidae represented four species followed, Arcidae, Pectinidae, Grypharidae, Pinnidae, Ostreidae, Margaritidae, Psammobiidae, Lucinidae, Pharidae recorded only one species (Fig. 4).

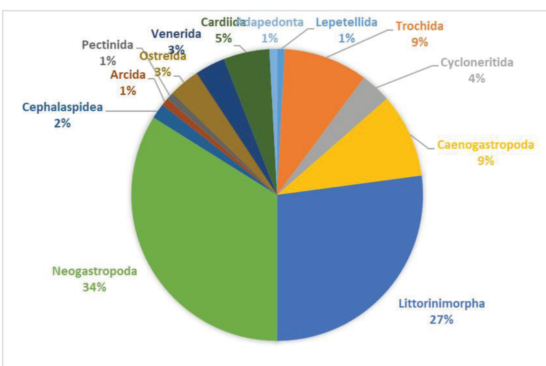


Fig. 2. Percentage composition of orders recorded during the study

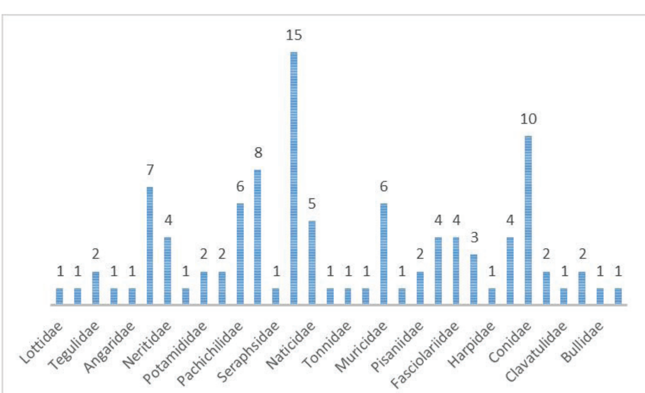


Fig. 3. Species compostion of families under the class Gastropoda recorded during the study

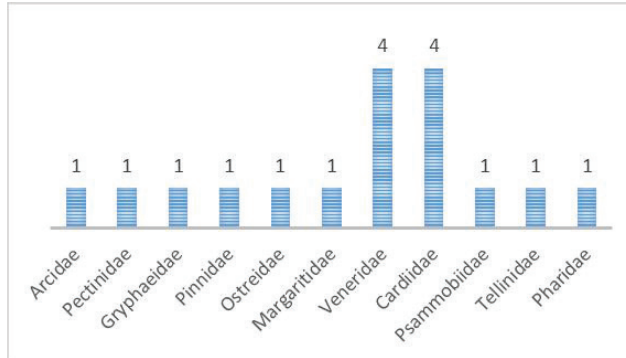


Fig. 4. Species compostion of families under class Bivalvia recorded during the study

Distribution in Different Study Sites

Of the recorded species, 83 species belonging to 35 families were observed from Kalipur followed by Durgapur (75 species; 35 families), Ross Island (45 species; 21 families), Lamiya Bay (43 species; 24 families), Aerial Bay (23 species; 15 families), Brush Island (27 species; 16 families) and lowest number of species were recorded from Ram Nagar (23 species; 15 families) (Fig. 5).

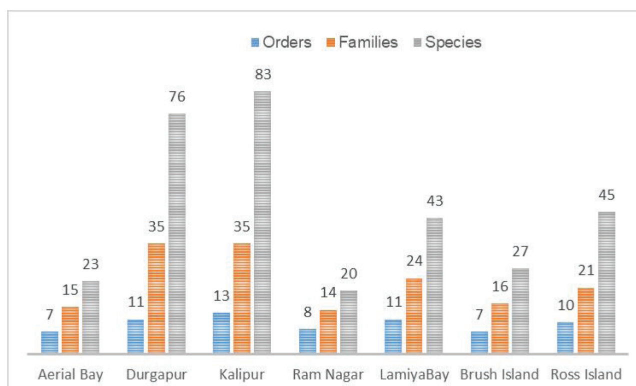


Fig. 5. Species composition in intertidal study areas of North Andaman Island

Bray Curtis similarity Index

Similarity indices were for the seven study sites (Fig. 6). Durgapur and Kalipur showed highest species similarity (0.74) whereas Aerial Bay showed very low similarity (0.28). The differences in the similarity mainly attributed to habitat variation, geographical isolation of the area.

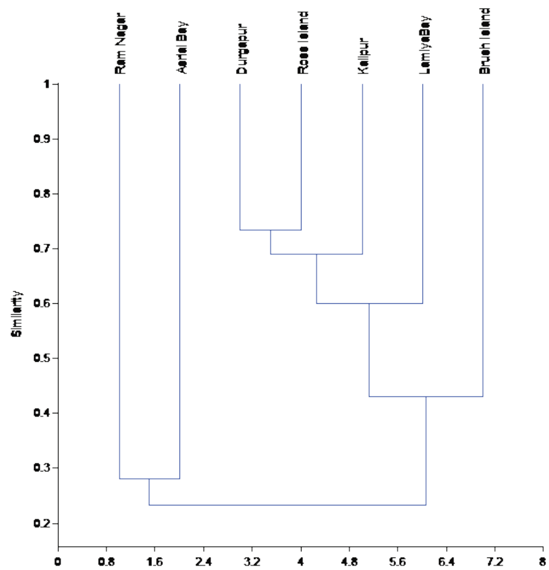


Fig. 6: Bray curtis similarity index among the selected study areas of North Andaman Island

Species Distribution in Habitats

The habitat comprising three types such as Rocky, Sandy, and Muddy substratum. During the surveys, we have encountered 89 species of both Gastropoda and Bivalvia at rocky intertidal region followed by 58 species at sandy shore whereas only 20 species found at muddy substratum. Sorensons similarity among habitats calculated (Table 3). Rocky and Sandy substratum showed more similarity about 0.42 followed by Rocky and Muddy 0.17 while lowest similarity showed between Muddy and sandy substratum 0.08.

Table 3. Sorenson's similarity among various habitats

	Muddy	Sandy
Rocky	0.17	0.42
Muddy		0.08

Species Abundance

The species were categorized from very rare to very common species based on their distributional range following the methodology of Ahmadrez *et al.* (2012). Relatively Common (39 species), followed by Very rare (38 species), Rare (24 species), Common (12 species) and six species are Very common among the study areas (Fig. 7).

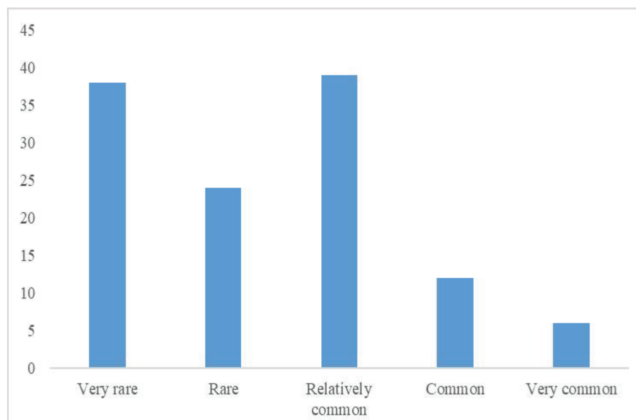


Fig. 7: The histogram shows abundance of very rare to very common molluscs species in intertidal areas of North Andaman Island

Table 4: Systematics and distribution of molluscs recorded during the study from intertidal region of North Andaman Island

Systematics	Aerial Bay	Durgapur	Kalipur	Ram Nagar	Lamiya Bay	Brush Island	Ross Island	Substratum	Abundance
Phylum Mollusca									
Class Gastropoda									
Family Lottidae Gray, 1840									
Patelloida saccharina (Linnaeus, 1758)		+	+		+		+	R	RC

Systematics	Aerial Bay	Durgapur	Kalipur	Ram Nagar	Lamiya Bay	Brush Island	Ross Island	Substratum	Abundance
Order Lepetellida									
Family Haliotidae Rafinesque, 1815									
Haliotis jacnensis Reeve, 1846		+	+		+		+	R	RC
Order Trochida									
Family Tegulidae Kuroda, Habe & Oyama, 1971									
Rochia nilotica (Linnaeus, 1767)		+	+		+		+	R	RC
Tectus fenestratus (Gmelin, 1791)		+	+		+		+	R	RC
Family Trochidae Rafinesque, 1815									
Monodonta labio (Linnaeus, 1758)						+		S	VR
Family Angaridae Gray, 1857									
Angaria delphinus (Linnaeus, 1758)	+	+	+		+	+	+	R, S	VC
Family Turbinidae Ratinesqe, 1815									
Astralium rhodostomum (Lamarck, 1822)		+						R	VR
Turbo argyrostomus Linnaeus, 1758			+					R, S	VR
Turbo bruneus (Röding, 1798)		+	+		+	+	+	R	C
Turbo crassus W. Wood, 1828		+	+		+		+	R	RC
Turbo sparverius Gmelin, 1791		+	+		+	+	+	R	C
Turbo petholatus Linnaeus, 1758						+		S	VR
Lunella cinerea (Born, 1778)		+	+			+		R, S, M	RC
Order Cycloneritida									
Family Neritidae Rafinesque, 1815									
Nerita albicilla Linnaeus, 1758	+	+	+	+	+	+	+	R, S	VC
Nerita chamaeleon Linnaeus, 1758			+					R	VR
Nerita costata Gmelin, 1791		+	+				+	R	RC
Nerita polita Linnaeus, 1758		+	+		+	+	+	R, S	C
Order Caenogastropoda									
Family Planaxidae Gray, 1850									
Planaxis sulcatus (Born, 1778)	+	+	+		+		+	R, S	C
Family Potamididae H. Adams & A. Adams, 1854									
Telescopium telescopium (Linnaeus, 1758)	+	+			+		+	M	RC
Terebralia palustris (Linnaeus, 1767)	+			+				M, R, S	R
Family Cerithiidae J. Fleming, 1822									
Cerithium nodulosum Bruguière, 1792	+	+	+				+	M	RC

Systematics	Aerial Bay	Durgapur	Kalipur	Ram Nagar	Lamiya Bay	Brush Island	Ross Island	Substratum	Abundance
Cerithidea obtusa (Lamarck, 1822)	+			+				M, S	R
Family Pachichilidae P. Fischer & Crosse, 1892									
Clypeomorus batillariaeformis Habe & Kosuge, 1966		+	+				+	R, M	RC
Faunus ater (Linnaeus, 1758)	+							R, M	VR
Rhinoclavis aspera (Linnaeus, 1758)	+	+	+				+	R, M	RC
Rhinoclavis vertagus (Linnaeus, 1767)			+					S, M	VR
Rhinoclavis articulata (A. Adams & Reeve, 1850)			+					R	VR
Rhinoclavis sinensis (Gmelin, 1791)		+	+				+	R	RC
Order Littorinimorpha									
Family Strombidae Rafinesque, 1815									
Lambis lambis (Linnaeus, 1758)		+	+		+	+	+	R, S	C
Lambis scorpius indomaris Abbott, 1961		+	+		+	+	+	S	C
Harpago chiragra (Linnaeus, 1758)		+	+				+	R	RC
Canarium labiatum (Röding, 1798)		+						R, S	VR
Canarium mutabile (Swainson, 1821)		+						S	VR
Laevistrombus canarium (Linnaeus, 1758)	+	+	+		+	+	+	R, S	VC
Dolomena variabilis (Swainson, 1820)		+			+			R	R
Gibberulus gibberulus (Linnaeus, 1758)					+		+	S	R
Family Seraphsidae Gray, 1853									
Terebellum terebellum (Linnaeus, 1758)			+					S	VR
Family Cypraeidae Rafinesque, 1015									
Arestorides argus (Linnaeus, 1758)		+	+	+	+		+	R, S	C
Bistolida kieneri (Hidalgo, 1906)		+	+					R	R
Erronea caurica (Linnaeus, 1758)		+	+		+		+	R, S	RC
Erronea errones (Linnaeus, 1758)			+					R	VR
Luria isabella (Linnaeus, 1758)		+	+		+			R	RC
Lyncina carneola (Linnaeus, 1758)		+	+		+		+	R, S	RC
Lyncina lynx (Linnaeus, 1758)		+	+	+		+	+	R	C
Lyncina vitellus (Linnaeus, 1758)		+	+					R	R
Mauritia arabica (Linnaeus, 1758)		+	+	+	+	+	+	R	VC
Monetaria annulus (Linnaeus, 1758)		+	+		+	+	+	R, S	C
Monetaria caputserpentis (Linnaeus, 1758)		+	+	+	+	+	+	R, S	VC
Monetaria moneta (Linnaeus, 1758)		+	+		+	+	+	R	C
Naria erosa (Linnaeus, 1758)		+	+		+	+	+	R	C
Palmadusta asellus (Linnaeus, 1758)			+					R	VR

Systematics	Aerial Bay	Durgapur	Kalipur	Ram Nagar	Lamiya Bay	Brush Island	Ross Island	Substratum	Abundance
Talparia talpa (Linnaeus, 1758)		+	+	+	+		+	R, S	C
Family Naticidae Forbes, 1838									
Naticarius onca (Röding, 1798)			+		+			R, S	R
Mammilla sebae (Récluz, 1844)	+			+				R, S, M	R
Notocochlis gualtieriana (Récluz, 1844)	+		+					R, M	R
Polinices flemingianus (Récluz, 1844)		+						R	VR
Polinices mammilla (Linnaeus, 1758)			+					R	VR
Family Cassididae Latriella, 1825									
Casmaria ponderosa (Gmelin, 1791)			+			+		R	R
Family Tonnidae Suter, 1913 (1825)									
Tonna tessellata (Lamarck, 1816)					+			S	VR
Family Bursidae Thiele, 1925									
Bursa granularis (Röding, 1798)		+	+			+	+	R, S	RC
Order Neogastropoda									
Family Muricidae Rafinesque, 1815									
Coralliophila violacea (Kiener, 1836)		+						S	VR
Chicoreus brunneus (Link, 1807)		+	+				+	R	RC
Drupa morum Röding, 1798			+					R	VR
Volema myristica Röding, 1798		+	+	+			+	R	RC
Menathais tuberosa (Röding, 1798)		+	+		+		+	R	RC
Nassa serta (Bruguière, 1789)			+					R	VR
Family Turbinellidae Swainson, 1835									
Vasum turbinellus (Linnaeus, 1758)		+				+		R, S	R
Family Pisaniidae Gray, 1857									
Engina lineata (Reeve, 1846)			+		+			R	R
Engina mendicaria (Linnaeus, 1758)		+	+		+		+	R, S	RC
Family Nassaridae Iredale, 1916									
Nassarius coronatus (Bruguière, 1789)	+	+	+					S, M	RC
Nassarius distortus (A. Adams, 1852)			+					S, M	VR
Nassarius livescens (Philippi, 1849)	+							S, M	VR
Nassarius olivaceus (Bruguière, 1789)			+					S, M	VR
Family Fasciolariidae Gray, 1853									
Filifusus filamentosus (Röding, 1798)		+						R	VR
Latirus gibbulus (Gmelin, 1791)		+			+			R	R
Turrilatirus craticulatus (Linnaeus, 1758)			+					R	VR

Systematics	Aerial Bay	Durgapur	Kalipur	Ram Nagar	Lamiya Bay	Brush Island	Ross Island	Substratum	Abundance
Latirolagena smaragdulus (Linnaeus,1758)						+		R, S	VR
Family Mitridae Swainson, 1831									
Pterygia dactylus (Linnaeus, 1767)		+			+			R	R
Strigatella aurantia (Gmelin, 1791)		+	+		+	+		R	RC
Strigatella paupercula (Linnaeus, 1758)		+	+					R	R
Family Harpidae Bronn, 1849									
Harpa major Röding, 1798			+					S	VR
Family Olividae Latereille, 1825									
Oliva annulata (Gmelin, 1791)			+					S	VR
Oliva miniacea (Röding, 1798)		+	+					S	R
Oliva oliva (Linnaeus, 1798)			+					S	VR
Oliva sericea (Röding, 1798)		+	+	+				R, S	RC
Family Conidae Rafinesque, 1815									
Conus araneosus nicobaricus Hwass in Bruguière, 1792		+	+				+	R	RC
Conus capitaneus Linnaeus, 1758	+				+			R	R
Conus chaldaeus (Röding, 1798)	+			+				R, S	R
Conus coronatus Gmelin, 1791			+					R	VR
Conus ebraeus Linnaeus, 1758		+		+		+		R, S	RC
Conus eburneus Hwass in Bruguière, 1792		+	+				+	R	RC
Conus litteratus Linnaeus, 1758	+							R, M	VR
Conus lividus Hwass in Bruguière, 1792	+							R, M	VR
Conus rattus Hwass in Bruguière, 1792		+	+				+	R, S	RC
Conus striatus Linnaeus, 1758		+		+				R, S	R
Family Turridae H. Adams & A. Adams, 1853 (1838)									
Lophiotoma abbreviata (Reeve, 1843)		+						R, S	VR
Lophiotoma acuta (Perry, 1811)			+					R, S	VR
Family Clavatulidae Gray, 1853									
Turricula javana (Linnaeus, 1767)		+	+					R	R
Family Terebridae Morch, 1852									
Hastula cinerea(Born, 1778)	+							M	VR
Terebra subulata (Linnaeus, 1767)		+			+	+		R, S	RC
Order Cephalaspidea P. Fischer, 1883									
Family Bullidae Gray, 1827									
Bulla ampulla Linnaeus, 1758		+	+	+	+	+	+	S	VC

Systematics	Aerial Bay	Durgapur	Kalipur	Ram Nagar	Lamiya Bay	Brush Island	Ross Island	Substratum	Abundance
Family Haminoeidae Pilsbry, 1895									
Atys naucum (Linnaeus, 1758)		+	+	+				S	RC
Class Bivalvia									
Order Arcida Stoliczka, 1871									
Family Arcidae Lamarck, 1809									
Barbatia lacerata (Bruguière, 1789)			+					S	VR
Order Pectinida Gray, 1854									
Family Pectinidae Rafinesque, 1815									
Gloripallium pallium (Linnaeus, 1758)		+	+	+			+	S, R	RC
Order Ostreida Ferussac, 1822									
Family Gryphaeidae Vialov, 1936									
Hyotissa hyotis (Linnaeus, 1758)		+	+		+		+	R	RC
Family Pinnidae Leach, 1819									
Atrina vexillum (Born, 1778)		+						R	VR
Family Ostreidae Rafinesque, 1815									
Saccostrea cuccullata (Born, 1778)		+	+				+	R	RC
Family Margaritidae Blainville, 1824									
Pinctada margaritifera (Linnaeus, 1758)		+			+			R	R
Order Venerida Gray, 1854									
Family Veneridae Rafinesque, 1815									
Periglypta reticulata (Linnaeus, 1758)		+	+			+		R	RC
Periglypta puerpera (Linnaeus, 1771)		+						R	R
Gafrarium pectinatum (Linnaeus, 1758)	+	+			+			R, M	RC
Lioconcha ornata (Dilwyn, 1817)			+					S	VR
Order Cardiida Ferussac, 1822									
Family Cardiidae Lamarck, 1809									
Tridacna crocea Lamarck, 1819			+		+			R	R
Tridacna maxima (Röding, 1798)		+	+	+			+	R	RC
Vasticardium elongatum (Bruguière, 1789)	+		+					S	R
Vasticardium flavum (Linnaeus, 1758)	+	+				+		S	RC
Family Psammobiidae J. Fleming, 1828									
Asaphis violascens (Forsskål in Niebuhr, 1775)	+	+		+				S	RC
Family Tellinidae Blainville, 1814									
Tellinella cruciata (Spengler, 1798)			+					S	VR
Order Adapedonta Cossmann & Peyrot, 1909									

Systematics	Aerial Bay	Durgapur	Kalipur	Ram Nagar	Lamiya Bay	Brush Island	Ross Island	Substratum	Abundance
Family Pharidae H. Adams & A. Adams, 1856									
Siliqua radiata (Linnaeus, 1758)			+	+	+			S	RC

(+, presence; nil, absence; R, Rocky substratum; S, Sandy substratum; M, Muddy substratum; VR, Very Rare; R, Rare; RC, Relatively Common; C, Common; VC, Very Common

Discussion

This study was carried out to assess the distribution and species composition of molluscan fauna especially on Gastropoda and Bivalvia in the intertidal regions of North Andaman Island. The surveys were conducted at selected seven sampling sites of rocky, sandy and muddy intertidal region revealed 119 species (89 gastropods and 17 bivalvia) that are commonly inhabit in North Andaman Coasts. Although, the Andaman and Nicobar archipelago are estimated to harbor 983 species molluscs (except opisthobranchs) belonging to 67 families (Mondal *et al.,* 2018). There is always fluctuation of species number because of more attention on addition or describing new records or new species from these Islands. Moreover, only few researches have been focused on diversity and distribution, quantitative analysis and species assemblages around North Andaman Coasts (Jeeva *et al.,* 2018). Their studies limited to Kalipur intertidal region and recorded only 20 species. In the present study 119 species were identified among them most of Mollusca taxa have been reported by Subba Rao (2003), Subba Rao and Dey (2010) of Indian Seashells (Part I) and Catalogue of Marine Molluscs of Andaman and Nicobar Islands. Recently, Dey (2016) has published Catalogue of Marine Molluscs of India.

Rocky shores provides heterogeneous environments due to their various substrate composition and structure and they support numerous habitats for flora and fauna (Araujo *et al.*, 2005; Cruz *et al.*, 2014). Gastropods are largest class of Mollusca compresses 80% of phylum Mollusca (Strong *et al.,* 2008). Recently, Pandey *et al.* (2016) substantiated habitat heterogeneity is important variable for the growth and survival of gastropod species. The distribution of intertidal organisms influenced by physical factors and ecological communities vary widely through time and space (Susintowati *et al.,* 2019). Species similarity and distribution of species attributed by habitat heterogeneity such as coralline rocks, flat rocks, rocky patches, mangrove substratum and geographical distance. Bray-Curtis similarity showed Durgapur and Ross Island showed highest species similarity (0.74) because of both locations share habitat structural complexity and near geographical distance. The study area Ram Nagar and Aerial Bay recorded lowest species similarity (0.28) and lack of substratum complexity due to contain sand and muddy area, and nearby fresh water runoff.

The highest abundance of relatively common species (32.77%) in comparison with other division while only 5.04% of very common species were noted during the study. This could be substrate quality, physio-chemical factors, environmental factors and other biological characteristics of intertidal zones influencing the distribution and species composition of intertidal regions of North Andaman Island.

The distribution of limped (*Patelloida saccharina*) and abalone shells (*Haliotis jacnensis*) prefers only rocky substratum. These shells are found in upper, middle and lower rocky intertidal regions. The shells of family Tegulidae, Trochidae, Angaridae and turbinidae are common in Andaman Islands could frequently encounter in almost all intertidal regions, most of shells were found below the rocks, and crevices. Hermit crabs were occupied most of the dead shells in the upper intertidal regions. The shells of family Neritidae are very common, *Nerita costata, N. polita* were prefers upper and middle rocky intertidal region. Live *N. albicilla* were observed at rocky upper to lower intertidal regions whereas most of dead *N. albicilla* were found in sandy shore. *Nerita chamaeleon*

Plate 1: a - *Patelloida saccharina* (Linnaeus, 1758); b - *Haliotis jacnensis* Reeve, 1846; c - *Rochia nilotica* (Linnaeus, 1767); d - *Tectus fenestratus* (Gmelin, 1791); e - *Monodonta labio* (Linnaeus, 1758); f - *Angaria delphinus* (Linnaeus, 1758); g - *Astralium rhodostomum* (Lamarck, 1822); h - *Turbo argyrostomus* Linnaeus, 1758; I - *Turbo sparverius* Gmelin, 1791; j - *Turbo petholatus* Linnaeus, 1758; k - *Lunella cinerea* (Born, 1778); l - *Nerita albicilla* Linnaeus, 1758; m - *Nerita chamaeleon* Linnaeus, 1758; n - *Nerita costata* Gmelin, 1791; o - *Nerita polita* Linnaeus, 1758; p - *Planaxis sulcatus* (Born, 1778); q - *Telescopium telescopium* (Linnaeus, 1758); r - *Terebalia palustris* (Linnaeus); s - *Clypeomorus batillariaeformis* Habe & Kosuge, 1966; t - *Rhinoclavis sinensis* (Gmelin, 1791)

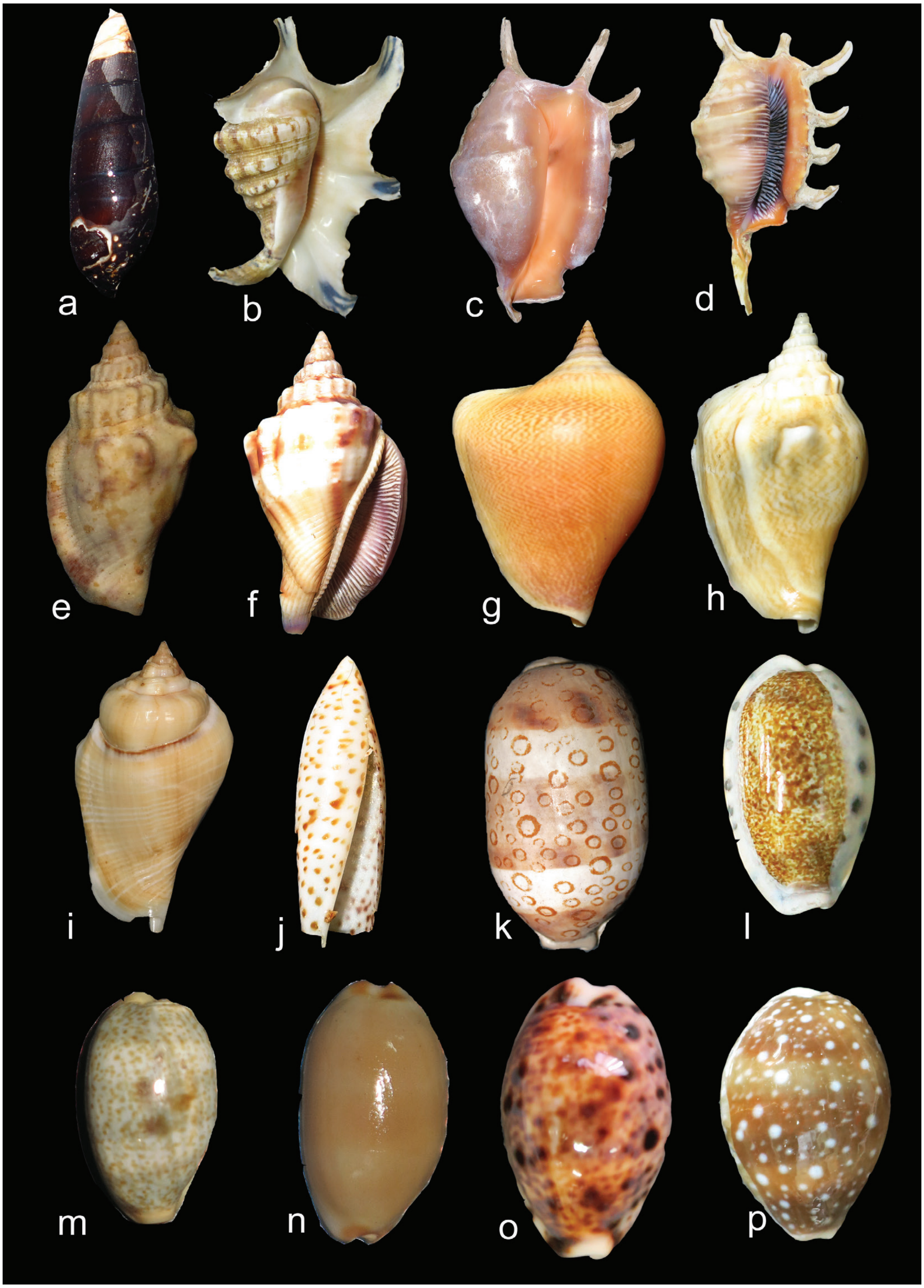


Plate 2: a - *Faunus ater* (Linnaeus, 1758); b - *Harpago chiragra* (Linnaeus, 1758); c - *Lambis lambis* (Linnaeus, 1758); d - *Lambis scorpius indomaris* Abbott, 1961; e - *Canarium labiatum* (Röding, 1798); f - *Canarium mutabile* (Swainson, 1821); g - *Laevistrombus canarium* (Linnaeus, 1758); h - *Dolomena variabilis* (Swainson, 1820); I - *Gibberulus gibberulus* (Linnaeus, 1758); j - *Terebellum terebellum* (Linnaeus, 1758); k - *Arestorides argus* (Linnaeus, 1758); l - *Erronea caurica* (Linnaeus, 1758); m - *Erronea errones* (Linnaeus, 1758); n - *Luria isabella* (Linnaeus, 1758); o - *Lyncina lynx* (Linnaeus, 1758); p - *Lyncina vitellus* (Linnaeus, 1758)

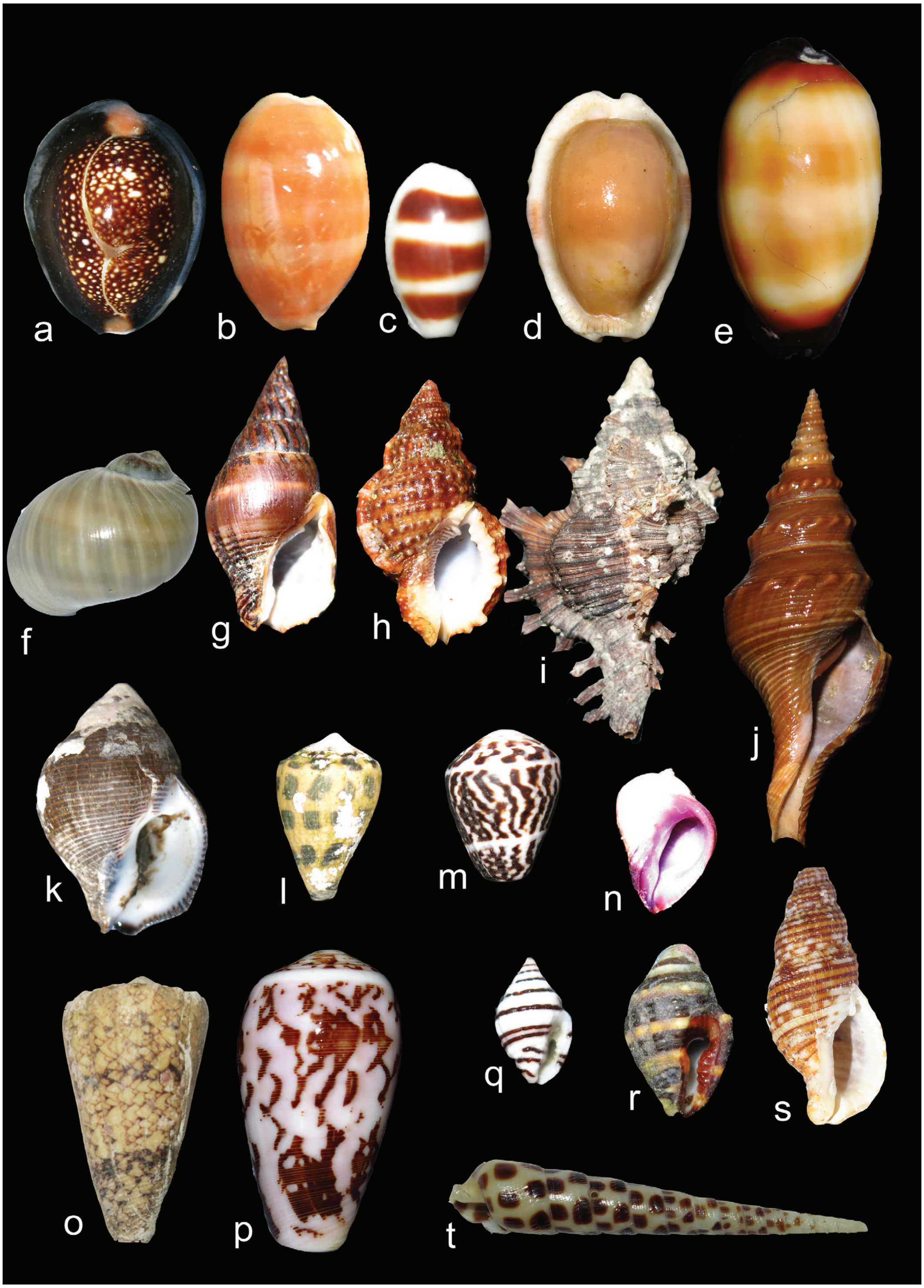


Plate 3: a - *Monetaria caputserpentis* (Linnaeus, 1758); b - *Lyncina carneola* (Linnaeus, 1758); c - *Palmadusta asellus* (Linnaeus, 1758); d - *Naria erosa* (Linnaeus, 1758); e - *Talparia talpa* (Linnaeus, 1758); f - *Notocochlis gualtieriana* (Récluz, 1844); g - *Nassarius olivaceus* (Bruguière, 1789); h - *Bursa granularis* (Röding, 1798); I - *Chicoreus brunneus* (Link, 1807); j - *Turricula javana* (Linnaeus, 1767); k - *Latirolagena smaragdulus* (Linnaeus,1758); l - *Conus ebraeus* Linnaeus, 1758; m - *Conus chaldaeus* (Röding, 1798); n - *Coralliophila violacea* (Kiener, 1836); o - *Conus araneosus nicobaricus* Hwass in Bruguière, 1792; p - *Conus striatus* Linnaeus, 1758; q - *Engina lineata* (Reeve, 1846); r - *Engina mendicaria* (Linnaeus, 1758); s - *Turrilatirus craticulatus* (Linnaeus, 1758); t - *Terebra subulata* (Linnaeus, 1767)

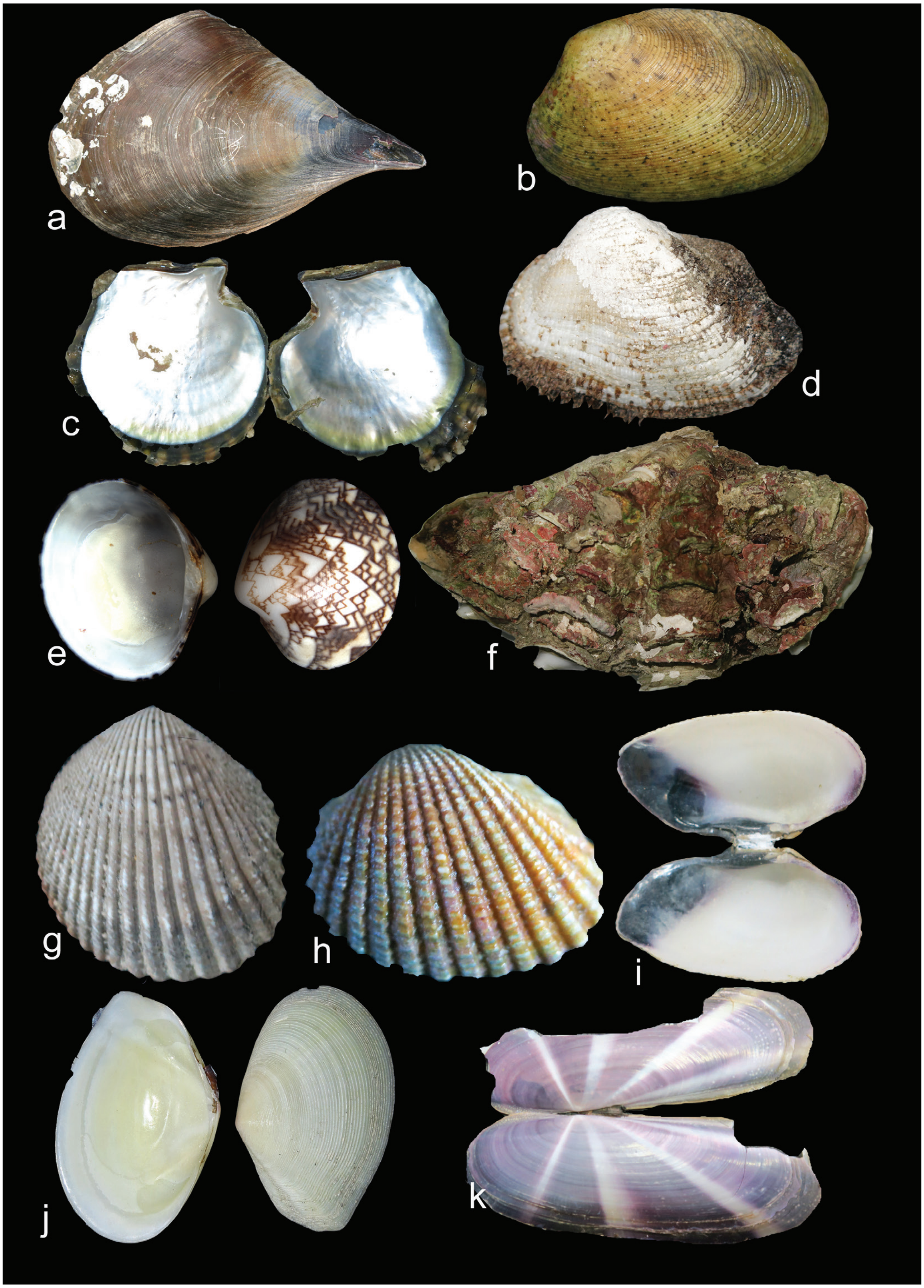


Plate 4: a - *Atrina vexillum* (Born, 1778); b - *Periglypta puerpera* (Linnaeus, 1771); c - *Pinctada margaritifera* (Linnaeus, 1758); d - *Barbatia obliquata* (Wood, 1828); e *Lioconcha ornata* (Dilwyn, 1817); f - *Tridacna maxima* (Röding, 1798); g - *Vasticardium elongatum* (Bruguière, 1789); h - *Vasticardium flavum* (Linnaeus, 1758); I - *Asaphis violascens* (Forsskål in Niebuhr, 1775); j - *Tellinella cruciata* (Spengler, 1798); kv- *Siliqua radiata* (Linnaeus, 1758)

Linnaeus, 1758 could found to be very rare only recorded from Kalipur intertidal region. The shells of Neritidae are generally euryhaline, herbivores, inhabit brackish and fresh water habitats (Tan and Climents, 2008).

The species of family Planaxidae found in rocky and muddy substratum, Potamididae (*Telescopium* and *Terebralia*) species found on muddy substrate>muddy and few shells were encountered at sandy region. Cerithidae shells were found at muddy and sandy substratum. The species of Pachichilidae were mostly found in Rocky and Muddy substratum. The high number of *Clypeomorus batillariaeformis* shells were encountered beneath rocks at upper intertidal region and small hermit crabs occupied most of dead shells. The common strombidae shells are noted in almost all intertidal regions of north Andaman Islands. Live *Lambis* species were observed at sandy substratum of Durgapur, Kalipur and Ross Island where dead shells were found at Brush Island and Ram Nagar Beach and considered as sea washed shells.

The snorkeling at Durgapur subtidal region resulted vast area covered with seagrass, seaweed and reef constitute live corals and their associated fauna. Moreover, most of shore seine carried out by fishermen (local fishing) at Durgapur area. The interesting fact we have noted during the surveys at Durgapur intertidal region i.e. encountered large number of sea washed dead shells of *Laevistrombus canarium*, could be attributed reason behind most of shells affected by local fishing and washed towards the shore. During the study we have recorded only single specimen of empty *Terebellum terebellum* (Linnaeus, 1758) belonging to Seraphsidae at sandy bottom of Kalipur intertidal region. Fifteen species of family cypraeidae were noted; they are common and found everywhere at intertidal regions (beneath the rocks, crevices and rocky pools) from upper sandy shore (seawashed shells) increasing live specimens towards the sea. The species of family Naticidae (*Natica*, *Naticarius*, *Notocochlis*, *Mammilla* and *Polinices*) found live and mostly prefers sandy> rocky>muddy intertidal region.

A single dead shell of *Tonna tessellata* (Tonnidae) found at upper sandy intertidal of Lamiya Bay. The species of Bursidae, Muricidae, Turbinellidae, Pisannidae and Nassaridae, Fasciolariidae, Mitridae, Harpidae found at almost all intertidal regions specimen number increasing upper>mid>lower intertidal regions of study areas. Species of family Olividae are only found at Durgapur and Kalipur intertidal areas, among four species *Oliva oliva* and *Oliva annulata* found live mostly preferred at sand pools (beneath huge rocks) and Conidae species are common, found small specimen (*Conus chaldeus*, *C. ebraeus*) to large specimen (*Conus litteratus*) at North Andaman intertidal areas.

The species of Turridae, Clavatulidae, Terebridae were found very rarely from only few locations. *Bulla ampulla* was common in all intertidal regions, and large number of dead specimens were recorded at Durgapur, same wise *Atys naucum* also found at Durgapur and Kalipur that could be probably because of local fishing activities. The species family Cardidae are common inhabitants of Indo-Pacific coral reef benthic communities in shallower waters (Jantzen *et al.*, 2008). *Tridacna* species are common reef dwellers mostly founds in lower intertidal regions of North Andaman Island. Most common specimens of dead shell of marine bivalves belonging to the family Pectinidae, Gryphaeidae, Pinnidae, Ostreidae, Margaritidae, Veneridae were found in the intertidal regions of almost all regions of North Andaman Island. Most oysters are very important to consume as food (Boominathan *et al.*, 2008). Bivalves could possibly attach to calcareous substratum, gaps of the cracks and rocky because of their borrowing nature. *Siliqua radiata* commonly called sunset shells, sandy bottom of shores in small burrows (Sujit *et al.,* 2010). Sometimes they found in various calcareous hard materials lying in the muddy substratum (Joseph and Ramesh Babu, 2014).

Present study reveals that habitat (rock, muddy and sand) complexity is one of the major attributes to assemblage of Mollusca fauna. Most of mollusca species were observed in rocky intertidal regions. This is baseline data for record of species composition and taxa distribution of molluscs intertidal region. Furthermore, sampling at other localities and in other habitats, is required for prepare the comprehensive list of molluscan fauna of this region.

Acknowledgements

The authors are grateful to Dr. Kailash Chandra, Director, Zoological Survey of India, Ministry of Environment, Forest and Climate Change, Government of India for providing facilities and encouragement. In addition, our sincere thanks to the Officials of Department of Environment, and Forests, Andaman and Nicobar Islands for providing logistic support during the field surveys.

References

Abbott, R., and Dance, S.P. 1990. Compendium of seashells: A colour guide to more than 42000 of the world's marine shells. N.S.W: Crawford House, Bathurst.

Ahmadreza, K., Zahra, B. and Mohammadreza, S. 2012. The gastropoda fauna along the Busherh Province Intertial Zone of the Persium Gulf. *Journal of the Persium Gulf (Marine Science.* 3(9): 33-42.

Anbalagan, T. and V. Deepak Samuel 2012. Common Molluscs of Gulf of Mannar, Publication No. 23, 66 p.

Ansari, Z.A., Abidi, S.A.H. and Haridevi, C.K., 2006. Records of auger shells (neogastropoda: terebridae) from Andaman and Nicobar Islands. *Seshaiyana*, 14(1): 1-8.

Apte, D.A., 2014. Sea Shells of India. An Illustrated Guide to Common Gastropods. Bombay Natural History Society & Oxford University Press, Mumbai, 197pp

Baharuddin, N., Basri, N B. and Syawal N.H. 2018. Marine gastropods (Gastropods: Mollusca) diversity and distribution on intertidal rocky shores of Terengganu, Peninsular Malaysia. *AACL Bioflux* 11(4): 1144-1154.

Boominathan, M., Chandran, M.D.S., Ramachandra, T.V., 2008. Economic Valuation of Bivalves in the Aghanashini Estuary, West Coast, Karnataka. ENVIS Technical Report: 30. Centre for Ecological Sciences, Indian Institute of Science, Bangalore, India.

Daniel, A. and Rajagopal, A.S. 1974. Molluscs of economic value from the Great Nicobar Islands. *Journal of Bombay Natural History Society*, 70(2): 394-398.

Darwin, Ch and Padmavathi, P. 2017. Diversity of Malacofauna from the Paeru and Moosy bckwaters of Prakasam district, Andhra Pradesh, India. *Journal of Entomology and zoological Studies.* 5(4): 881-887.

Dey A. 2016. *Catalogue of Marine Molluscs (Polyplacophora and Gastropoda)* (Published by Director of Zoological Survey of India), pp. 687.

Ellen, E.S., Olivier, W.F.P. and Bouchet, P. 2008. Gloval diversity of gastropods (Gastropoda: Mollusca) in freshwater. *Hydrobiologia* 595: 149-166.

Franklin, J.B., Venkateshwaran, P., Vinithkumar, N.V. and Kirubagaran, R. 2013. Four new records of family Conidae (Caenogastropoda: Mollusca) from Andaman Islands. *Zootaxa* 3635(1): 81-86.

Franklin, J.B., Vinithkumar, N.V. and Kirubagaran, R. 2014. Two New Records of Marine Gastropodsfrom Andaman and Nicobar Islands, India. *Marine Biodiversity Records* 7(41):1-5.

http://www.andamans.gov.in IUCN, 2018.

Jantzen, C., Wild, C., El-Zibdah, M., Roa-Quiaoit, H.A., Haacke, C. and Richter, C., 2008. Photosynthetic performance of giant clams, Tridacna maxima and T. squamosa, Red Sea. *Marine Biology*. 155(2):211-221.

Jeeva, C., Mohan, PM., Sabith, K.K.D.B., Ubare, V.V., Murauganantham, M. and Kumari, R.K. 2018. Distribution of gastropods int eh intertidal environment of south, middle and north Andaman Islands, India. *Open Journal of Marine science* 8: 173-195.

Molles M. C. J., 2016 Ecology: concepts and applications. Seventh edition, McGraw Hill Education, New York, USA.

Mondal, T. 2018. Molluscs. In: *Faunal Diversity of Biogeographic Zone: Islands of India*: 353-372. (Published by the Director, Zool. Surv. India, Kolkata)

Pandey, V., Thiruchitrambalam, G and Satyam, K. 2018. Habitat heterogeneity determines structural properties of intertidal gastropods assemblages in a pristine tropical island ecosystem. *Indian Journal of Geo-Marine Sciences*. 47(4): 846-853.

Raghunathan C, Tewari A, Joshi HV, Kumar VGS, Trivedi RH, Khambhaty Y. Impact of turbidity on intertidal macrofauna at Gopnath, Mahuva and Veraval coasts (west coast of India). *Indian Journal of Marine Sciences*. 2003; 32(3):214-221.

Rajagopal, A.S. and Daniel, A. 1973. Boring organisms of the Great Nicobar Islands (Mollusca: Teredinidae). *Journal of Bombay Natural History Society*. 69(3): 676-678.

Ramakrishna and Dey, A. 2003. Manual on the identification of Schedule Molluscs from India. Zoological Survey of India, Kolkata, 40 p.

Ramkrishna and Dey, A. 2010. Annotated checklist of Indian Marine Molluscs (Cephalopoda, Bivalvia and Scaphopoda) Part-1. Occasional Paper No. 320: 1-357 (Published by the Director, Zool. Surv. India, Kolkata).

Rosenberg, G. 2014. A new critical estimate of named species-level diversity of the recent Mollusca. *American Malacological Bulletin*, *32*(2), pp.308-322.

Subba Rao, N V. 2003. *Indian Seashells (Part-I): Polyplacophora and Gastropoda* (Records of *Zool. surv. India*) 192: 416pp.

Subba Rao, N.V. and Dey, A. 1991. Composition and distribution of marine molluscs of Andaman and Nicobar Islands. *Journal of the Andaman Science Association* 4(1): 61-66.

Subba Rao, N.V. and Dey, A. 2000. Catalogue of Marine Molluscs of Andaman and Nicobar Islands. Records of the Zoological Survey of India, Occasional Publications, *Hoogly printing Co. Ltd* (A Governmentof India Enterprises), Kolkata pp. 323.

Susintowati, S., Puniawati, N., Poedjirahajoe, E., Handayani, N.S.N. and Hadisusanto, S., 2019. The intertidal gastropods (Gastropoda: Mollusca) diversity and taxa distribution in Alas Purwo National Park, East Java, Indonesia. Biodiversitas *Journal of Biological Diversity*, 20(7).

Tan, S.K. and Clements, R., 2008. Taxonomy and distribution of the Neritidae (Mollusca: Gastropoda) in Singapore. *Zoological studies*, 47(4):481-494.

Tikader, B.K., Daniel, A. and Subba Rao, N.V. 1986. Sea shore animals of Andaman & Nicobar Islands, Records of Zoological Survey of India. Printed at The Radiant Process Private Limited, Calcutta, India.

Underwood, A.J. and Chapman, M.G., 1996. Scales of spatial patterns of distribution of intertidal invertebrates. *Oecologia*, 107(2): 212-224.

Venkataraman, K., Satyanarayana, C., Alfred, J.R.B. and Wolstenholme,J., 2003. Handbook on Hard Corals of India. pp. 1- 266. Published by the Director, Zoological Survey of India, Kolkata.

Wong, N.L.W.S. and Arshad, A. 2011. A Brief Review on Marine Shelled Mollusca (Gastropoda and Bivalvia) Record in Malaysia. *Journal of Fisheries and Aquatic Science*, 6: 669-699.

WoRMS (2020). Mollusca. Accessed at: http://www.marinespecies.org/ aphia.php?p= taxdetails&id=51 on 2020-06-12.

Received : 14th February 2020 Accepted : 4th May 2020

Brachyuran Crabs Associated with Echinoderms from the Andaman and Nicobar Islands, India

Naveen Kumar Nigam*, S. Rajendra and C. Sivaperuman
Zoological Survey of India, Andaman and Nicobar Regional Centre, Port Blair-744102, Andaman and Nicobar Islands
Corresponding author: naveennigam88@gmail.com

Abstract

The present paper provides five symbiotic brachyuran crabs belonging to two families of Pilumnidae and Portunidae which are associated with echinoderms of Andaman and Nicobar Islands. They are associated with three classes of Echinodermata, such as Echinoidea, Holothuroidea and Crinoidea. The specimens were collected from intertidal and subtidal habitats of South Andaman,North Andaman and Great Nicobar Island. The brachyurans namely, *Ceratocarcinus longimanus* White, 1847*, Harrovia elegans* de Man, 1887and *Tiaramedon spinosum* (Miers, 1879) were associated with Crinoidea (Feather stars)while *Echinoecus pentagonus* (A. Milne-Edwards, 1879)is reported from Echinoidea (Sea urchin). One Portunid crab, *Lissocarcinus orbicularis* Dana, 1852 was recorded from Holothuroidea (Sea cucumber). *Tiaramedon sphinosum* (Miers, 1879)was earlier recorded from Gulf of Mannar and it is recorded to Andaman Islands, while, *Harrovia elegans*de Man, 1887and*Lissocarcinus orbicularis* Dana, 1852were listed in literature from Andaman Islands with their description and host details.

Keywords: Andaman, Nicobar, Association, Echinoderms, malacostraca, symbiosis

Introduction

Andaman and Nicobar Islands are situated between Bay of Bengal and Andaman sea, contributing one of the major coral reef ecosystems in India. The Andaman Islands (10°30′-14º; 92º-93º) are emerged is a part of a mountain chain and lie on a ridge, which extends southward from the Irrawaddy delta area of Burma. The Andaman group is separated from the Nicobar group by Ten Degree Channel about 150 km wide. The Andaman and Nicobar Islands have fringing reefs around many islands, and a long barrier reef (329 km) on the west coast (Tikadar and Das, 1985).

The reef-associated biodiversity especially Echinoderm fauna of the Andaman and Nicobar Islands is well diversified with 478 species under 108 families and 48 orders. However, the studies on the associate species of Echinodermata symbionts were scanty (Sastry, 1981; Castro *et al.,* 1995; Roy and Nandi, 2012; Kumaralingam *et al.,* 2013, 2017). A total of 588 species of brachyuran crabs belonging to 275 genera and 58 families have been reported from Andaman and Nicobar Islands (Trivedi *et al.,* 2018). Many of them have shown to display specific animal associations, especially with marine benthic invertebrates (Castro, 1989). Two families *i.e.* Pilumnidae and Portunidae of brachyuran crabs are closely associated with various species of echinoderms. In Andaman and Nicobar Islands, only five species of Echinoderms are associated with brachyuran crabs have been reported (Dev Roy and Nandini, 2012). The species of the families, Eumedoninae and Caphyrinae crabs are obligate symbionts of Feather stars (Comatulids), Sea urchin (Regular echinoids) and Sea cucumbers (Holothuroids). The present paper dealt with echinoderms associated brachyuran crabs of Andaman and Nicobar Islands with new record of *Tiaramedon sphinosum* (Miers, 1879) to Andaman Islands, and *Harrovia elegans* de Man, 1887 and *Lissocarcinus orbicularis* Dana, 1852are to Nicobar Islands.

Methods

The surveys have been carried out in intertidal and subtidal habitats of Andaman and Nicobar Islands (Fig. 1). The specimens were collected by hand picking and scuba diving at subtidal regions. Field photographs of Echinoderms and their associates were taken using

Canon G7X. The collected specimens with their associates were preserved in ethanol for further study. Identification of associated brachyuran crabs were based on external morphological characters by using standard literature (Crosnier, 1962; Clark and Rowe, 1971; Castro, 1995; Chia and Ng, 1998; Chia *et al.*, 1999; Ng and Jeng, 1999; Evans, 2016; Kumaralingam *et al.*, 2017) and terminology used by follows Ng *et al.* (2008). Photographs and measurements of crabs were taken using a digital camera attached to the Stereo Zoom Microscope (LEICA M 205A). The specimens were deposited in the National Zoological Collection, Andaman Nicobar Regional Centre, Zoological Survey of India, Port Blair. Abbreviations used are CL (Carapace Length), CW (Carapace Width).

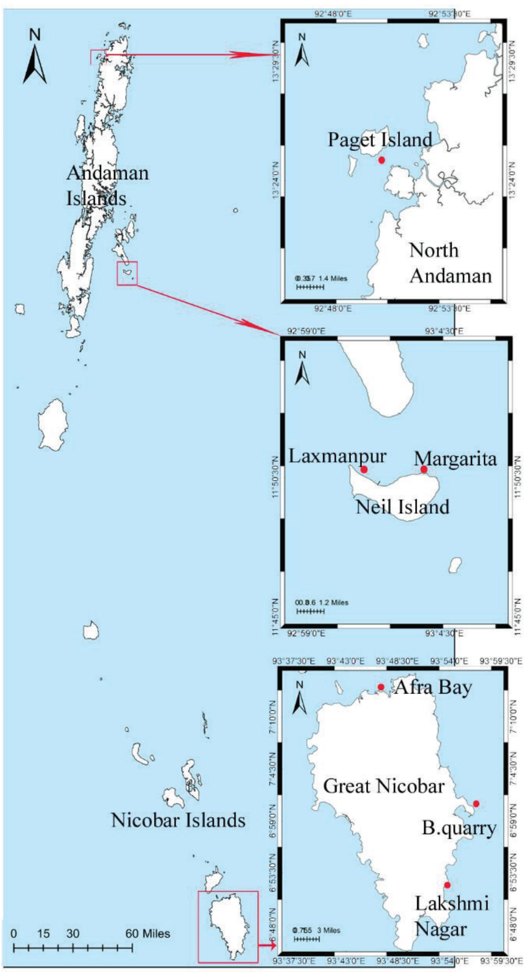


Fig. 1: Map showing the study areas of Andaman and Nicobar Islands

Results and discussion

During the study we have documented five species of brachyuran crabs which are obligate associated with echinoderms. The systematics, diagnosis, geographical distribution and their host details are presented in this paper (Table1).

Table1. Systematics of brachyuran crabs

Systematics
Phylum Arthropoda von Siebold, 1848
Subphylum Crustacea Brünnich, 1772
Class Malacostraca Latreille, 1802
Order Decapoda Latreille, 1802
Infraorder Brachyura Latreille, 1802
Family Pilumnidae Samouelle, 1819
Subfamily Eumedoninae Dana, 1852
Genus *Ceratocarcinus* White, 1847
***Ceratocarcinus longimanus* White, 1847**
Genus *Echinoecus* Rathbun, 1894
***Echinoecus pentagonus* (A. Milne-Edwards, 1879)**
Genus *Harrovia* Adams & White, 1849
***Harrovia elegans* de Man, 1887**
Genus *Tiaramedon* D.G.B. Chia & P.K.L. Ng, 1998
***Tiaramedon spinosum* (Miers, 1879)**
Family Portunidae Rafinesque, 1815
Subfamily Caphyrinae Paulson, 1875
Genus *Lissocarcinus* Adams & White, 1849
***Lissocarcinus orbicularis* Dana, 1852**

***1. Ceratocarcinus longimanus*White, 1847**
(Fig.2a-c)

Common Name: Horned Crinoid Crab

Type Locality: Malaysia (White, 1847)

Ceratocarcinus longimanus White, 1847: 125; Adams & White, 1848-1849: 34, pl. 6: Figs. 6&6a; Castro *et al.*, 1995: 239, Fig. 1; Chia and Ng, 1998: 497, Figs. 1&2; Kumaralingam *et al.*, 2017: 133, Fig. 114.

Synonyms

Ceratocarcinus speciosus Dana, 1851; *Ceratocarcinus dilatatus* A. Milne-Edwards, 1872 *Ceratocarcinus intermedius* Zehntner, 1894.

Material examined: One female (CL 8.7 mm, CW 11.5mm), Laxmanpur, Neil Island (Lat: 11°50.807' N; Long: 93°01.280' E), South Andaman, 12m, Coll. date. 21 March 2018, Reg. No. ZSI/ANRC/M/24895, Coll. by N.K. Nigam; One female (CL 9.2 mm, CW 11.4 mm) Paget Island (Lat:13°24.961' N; Long:92°50.286' E) North Andaman, 7m,Coll. date21 February 2018, Reg. No. ZSI/ANRC/M/25060, Coll. by N.K. Nigam.

Hosts: The present specimens were collected from Comatulid feather star *Comanthus parvicirrus.*Generally, this species associates with *Zygometra* sp. (Stevcic *et al.,* 1988)*Comanthus gisleni, Comanthus parvicirrus* and *Comatula purpurea* (Fabricius & Dale, 1993),*Comatella stelligera*, *Comatella nigra*, *Oxycomanthus bennetti*, *Comanthina scheglii*, *Comanthus parvicirrus*, *Capillaster multiradiatus*, *Clarkcomanthus* sp. *Comaster tenella*, *Himerometra robustipinna* (Castro *et al.*, 1995) and unidentified Comatulid (Comatulidae) (Kumaralingam *et al.,* 2017).

Geographical distribution: This species was reported from Nancowry (Nicobar Islands), Singapore, Malaysia, Indonesia, Papua New Guinea, Australia, New Caledonia, Solomon Islands, Fiji, Philippines, Palau, Japan (Castro *et al.,* 1995; Chia and Ng, 1998); Indo-west pacific regions (Miers, 1886; Balss, 1922; Flipse, 1930; Serene *et al.,* 1958; Estampador, 1937; Griffin and Yaldwyn, 1968; Serene, 1968; Monod and Serene, 1976; Stevcic *et al.,* 1988). Recent records from Andaman Islands, India (Dev Roy and Nandi, 2012; Kumaralingam *et al.,* 2017; Nigam *et al*. present study).

Remarks: Castro *et al.* (1995) provided the detailed diagnosis and description of *Ceratocarcinus longimanus* from tropical Indo-west Pacific region. Chia and Ng (1998) revised the genus *Ceratocarcinus* with description of two new species. This species characterized by the inner supraorbital teeth longer than broad; large tubercles on protogastric, metagastric, branchial and cardiac regions of carapace; anterolateral lobe 1-3 truncate, seldom fused with callosities, lower part of lobe three not often expanded to direct laterally except in very large specimens, lobe 4 very prominent, Hiterally directed; angle between anterolateral and posterolateral margins not as distinct; surfaces not as strongly tuberculated (Chia and Ng, 1998). *Ceratocarcinus longimanus* strictly associated with feather stars (Comatulids) and this symbiotic crab is typically located at the oral side of the host's central disk. This symbiotic brachyuran crab found on almost all comatulid species, which belonging to the family Comatulidae (Comasteridae) and Himerometridae (Castro *et al.,* 1995). Recently,Kumaralingam *et al.* (2017) have made documentation of *Ceratocarcinus longimanus* fromunidentified Comatulids. This species has not recorded from mainland India, and reported from the A & N Islands.

2. Echinoecus pentagonus
(A. Milne-Edwards, 1879) (Fig.2d-f& 3a)

Common Name: Sea Urchin Crab

Type locality: Mauritius(Milne-Edwards, 1879)

Eumedon pentagonus Milne Edwards A., 1879: 104.

Echinoecus pentagonus Chia *et al.*, 1999: 811, Figs. 1&2; Ng & Jeng, 1999: 268, Figs 1-2; Prakash *et al*., 2012: 62, Figs. 1&2; Kumarlingam *et al*., 2017; Meher and Thiruchitrambalam, 2019: 14774, Image 1, Fig. 2.

Synonymy: *Eumedonpentagonus* MilneEdwardsA.,1879; *Eumedon convictor*Bouvier and Seurat, 1905; *Liomedon pentagonus*Klunziger, 1906; *Eumedonus convictor*Laurie, 1915; *Eumedonus petiti* Gravier, 1922; *Eumedonus pentagonus*Ballas, 1922b; *Echinoecus rathbunae*Miyake, 1939; *Echinoecus rathbunae convictor*Miyake, 1939; *Echinoecus petiti nipponensis*Miyake, 1939; *Echinoecus klunzingeri*Miyake, 1939.

Material examined: One female specimen (CL 10.46mm, CW 9.99mm), Lakshmi Nagar, (Lat: 06°52.158'N; Long: 93°53.725'E), Great Nicobar Island, Intertidal, Coll. date9th August 2018, Reg. No. ZSI/ANRC/M/25061, Coll. by N.K. Nigam.

Hosts: The present specimen was collected from Sea urchin, *Echinothrix diadema*. This species commonly associated with *Diadema setosum,Diadema savignyi, Echinothrix calamaris, Echinothrix diadema, Pseudocentrotus depressus* and *Heterocentrotus mammillatus* (Chia *et al.*, 1999).

Geographical distribution: Recorded from Australia (Mather and Bennett, 1984; Chia *et al.*, 1999), Cocos Islands, Indian Ocean (Clark 1950; Tweedie, 1950; Yang 1979; Chia *et al.,* 1999), French Polynesia (Morrison, 1954, Holthuis, 1953; Chia *et al.*, 1999), Israel (Chia *et al.*, 1999), Hawaiian Islands (Rathbun, 1906; Castro, 1971; Castro, 1978; Van Dover *et al.*, 1986; Chia *et al.*, 1999), Indonesia (Serene *et al.*, 1974; Chia *et al.*, 1999), Japan (Rathbun, 1894; Balss, 1922; Miyake, 1939; Sakai, 1976; Nagai and Nomura,1988; Chia *et al.*, 1999), Kenya (Chia *et al.*, 1999), Kikambala (Chia *et al.*, 1999), Madagascar (Gravier, 1922; Chia *et al.*, 1999), Mauritius (Milne Edwards, 1879), Moluccas (Serene *et al.*, 1974), Mombassa (Chia *et al.*, 1999), Papua New Guinea (Bouvier and Seurat, 1905; Chia *et al.*, 1999), Ogasawara (Bonin) Island (Rathbun, 1894; Miyake, 1939), Philippines (Chia *et al.*, 1999), Red Sea (Klunzinger, 1906; Klunzinge, 1913; Chia *et al.*, 1999), South China Sea (Anonymous, 1974; Chen, 1975; Dai *et al.*, 1986; Dai and Yang, 1991; Chia *et al.*, 1999), South Korea (Kim and Chang, 1985), Sudan (Chia *et al.*, 1999), Thailand (Stevcic *et al.*, 1988; Chia *et al.*, 1999), Tuamotu Archipelago (Bouvier and Seurat, 1905; Nobili, 1907; Holthuis, 1953; Morrison, 1954),Vietnam (Serene, *et al.*, 1958; Chia *et al.*, 1999). Record from India: Lakshadweep (Prakash *et al.*, 2012; Kumarlingam *et al.*, 2017), Andaman Islands (Dey Roy and Nandi, 2012; Meher and Thiruchitrambalam, 2019), Car Nicobar Island (Sastry, 1981) and Great Nicobar Island (Nigam *et al*. present study).

Remarks: Chia *et al.* (1999) reviseded the genus *Echinoecus* and provide the detailed diagnosis and description of *Echinoecus pentagonus* with examined the holotype specimen collected by A. Milne Edwards from Mauritius.*Echinoecus pentagonus* characterized by sharp and longer rostrum, significantly distinguishes from other two species *Echinoecus nipponicus* and *Echinoecus sculptus*. As in agreement with previous record (Castro, 1971), thesymbiotic crab *Echinoecus pentagonus* female has been found to invade the rectum of sea urchin hosts species. Other sea urchin associated crab *Echinoecus nipponicus* always lives on the external surface (Chia *et al.,* 1999). While, *Echinoecussculptus* lives on oral region of helmet sea urchin *Colobocentrotus (Podophora) atratus* (Castro, 2015). Previously, this species has been recorded on sea urchin *Echinothrix diadema* from the Car Nicobar by Sastry (1981). Dev Roy and Nandi (2012) listed this species from Nicobar Islands. In 2019, Meher and Thiruchitrambalam was recorded from the Port Blair, Andaman Islands. The present study records of *Echinoecus pentagonus*from the Great Nicobar Island.

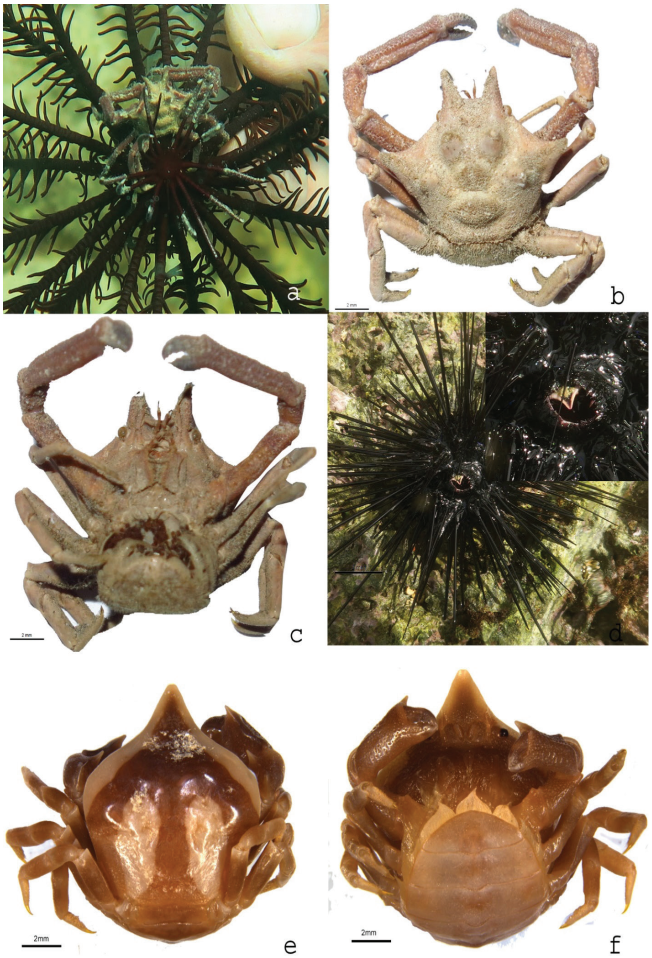


Figure 2: a-c. *Ceratocarcinus longimanus* White, 1847 (a. in-situ photograph, b. dorsal view, c. ventral view); d-f: *Echinoecus pentagonus* (A. Milne-Edwards, 1879) (d. in-situ photograph, e. dorsal view, f. ventral view)

***3. Harrovia elegans* De Man 1887** (Fig. 3b-d)

Common Name: Elegant Crinoid Crab

Type locality: Mergui Archipelago, Burma (Myanmar) (De Man 1887)

Harrovia elegans De Man, 1887-1888: 5, 21, pl. 1: Figs. 5, 6; Chia and Ng, 1998: 523, Figs. 14&15.

Synonymy: *Harrovia albolineata* Laurie, 1906

Material examined: One female specimen (CL 5.1 mm, CW 7.8 mm), B. Quarry (Lat: 07°00.737'N; Long: 93°56.821'E), Campbell Bay, Great Nicobar Island, 13m depth, Coll. date28th December 2017, Reg. No. ZSI/ANRC/M/25062, Coll. by N.K.Nigam.

Hosts: The present species *Harrovia elegans* was collected from Feather star *Comanthus parvicirrus.* Earlier this species recorded from *Lamprometra* sp. (Jones and Sankarankutty, 1961) and *Comanthus wahlbergii* (Jose and Kutty, 2020).

Geographical distribution: Records from Myanmar (De Man, 1887-1888), Indonesia (De Man, 1902; Chia and Ng, 1998),Vietnam (Serene *et al.*, 1958), Marshall Islands, Central Pacific Ocean (Garth, 1964; Castro, 1989),South Korea(Kim, 1970; Kim and Rho, 1972), Philippines (Serene and Vadon, 1981; Chia and Ng, 1998), Pakistan (Tirmizi and Kazmi, 1982),Somalia, Thailand (Castro, 1989; Chia and Ng 1998),Sri Lanka, Malaysia, South China Sea (Chia and Ng, 1998). Records from India- Gulf of Manaar (Laurie, 1906; Jones and Sankarankutty, 1961; Jose and Kutty, 2020) Andaman Islands and Nicobar Islands (Dev Roy and Nandi, 2012; Nigam *et al*. present record).

Remarks: Chia and Ng (1998) provided the detailed diagnosis and description of *Harrovia elegens* with neotype male specimen from Sri Lanka. *Harrovia elegens* characterized by the existence of two prominent teeth like anterolateral spines in their carapace and occurrence of dark bands on the white background of the carapace (Castro 1989; Serène *et al.,* 1958). The characters of *Harrovia elegans* resembles *Harrovia japonica* and it is distinguished by the form of the margins of the first and second anterolateral teeth are straight or subtruncate and no spiniform edges (Chia and Ng, 1998). Chia and Ng (1998) revised the genus *Harrovia* with clarification of *Harrovia albolineata* reported by Laurie (1906), Sankarankutty (1961) and Sankarankutty (1966) redetermined as *Harrovia elegans.* Recently this species was recorded by Dey Roy and Nandi (2012) from their survey in these islands. They have found the species from 51-200m depth range while the present specimen was found at subtidal 13m from Great Nicobar Island. Recently, the same species was recorded from Gulf of Mannar (Jose and Kutty, 2020). The present record of *Harrovia elegans* geographical range is here extending to Great Nicobar Island.

***4. Tiaramedon spinosum* (Miers, 1879)** (Fig. 3e-f)

Common Name: Unknown

Type locality: Australia(Miers, 1879)

Ceratocarcinus spinosus Miers, 1879c: 27, pl. 5, fig. 11*Tiaramedon spinosum* Chia & Ng, 1998: 508, figs 7-8; Ng and Jeng, 1999: 270, fig. 6; Mariyambi *et al.,* 2020: 3, Fig. 2.

Synonymy: *Ceratocarcinus spinosus* Miers, 1879

Host: *Tiaromedon spinosum* was collected from Feather star *Comanthus parvicirrus.* Earlier this species recorded from*Clarkcomanthus littoralis, Comanthus parvicirra, Comanthussuavia* and *Lamprometra klunzingeri* (Chia and Ng, 1998); *Comanthus gisleni* and *Stephanometra indica* (Fujita, 2011).

Geographical distribution: Records from Red Sea (Balss, 1924a, Gordon, 1934, Fishelson, 1973, Chia and Ng, 1998), Christmas Island (Chia and Ng, 1998), Japan (Sakai, 1954; Sakai, 1976a; Miyake, 1983; Fujita, 2011), Taiwan (Hwang and Yu, 1980), South China Sea (Serène *et al*., 1958), Borneo (Chia and Ng, 1998), Indonesia (Flipse, 1930; Serène *et al*., 1976; Chia and Ng, 1998), Papua New Guinea (Chia and Ng, 1998), Australia (Chia and Ng, 1998),New Caledonia (Chia and Ng, 1998), Niue (Chia and Ng, 1998), Israel, Malaysia (Chia and Ng, 1998). Record from India- Lakshadweep, Arabian Sea, Western Indian Ocean (Mariyambi *et al.,* 2020); Andaman Islands (Nigam *et al*., Present study).

Remarks: *Tiaramedon spinosum* is monotypic genus. Chia and Ng (1998) re-described and provided the detailed diagnosis and description of *Tiaramedon spinosum* from Australia Sea. *Tiaromedon spinosum* characterized by six spines prominent on the carapace, Carpus and propodus of chelipeds with distal spines (Sakai, 1976).The carapace of *Tiaramedonspinosum* is ornamented with very long spines. The length of the spines varies among specimens, but in almost all cases, the protogastric spines are the longest, even in juveniles (Chia and Ng, 1998). Recently Fujita (2011) have made the complete larval development documentation of *Tiaramedonspinosum* (Miers, 1879) from *Comanthus gisleni* and *Stephanometra indica.* In the present study material was observed from Neil Island, South Andaman and this is the new record to Andaman Islands.

Figure 3: a. *Echinoecus pentagonus* (A. Milne-Edwards, 1879) frontal view; b-d. *Harrovia elegans* de Man, 1887 (b. dorsal view, d. ventral view, e. frontal view); e,f. *Tiaramedon spinosum* (Miers, 1879) (e. in-situ photo showing the host, f. ex-situ photograph)

5. *Lissocarcinus orbicularis* Dana, 1852
(Figure 4 a-d)

Common name: Harlequin crab

Type locality: Fiji(Dana, 1852)

Lissocarcinus orbicularis Dana, 1852: 86, 288, pl. 18, fig. 1a-e; Crosnier, 1962: 25, Figs. 26, 27&31; Ng and Jeng, 1999: 270, figs 7-8; Evans, 2016: 116, Figs. 2.3d, 3-9.

Synonymy: *Lissocarcinus pulchellus* Müller, 1887

Material examined: One female specimen (CL6.8 mm, CW8 mm), Afra Bay (Lat: 07°12.425'N; Long: 93°46.398'E), Great Nicobar Island, 6m, dated. 27th December 2017, Reg. No. ZSI/ANRC/M/25063, Coll. by N.K. Nigam.

Hosts: The present study *Lissocarcinus orbicularis* collected from Sea cucumber, *Bohadschia* sp.Commonly this speciesfound onholothurians *Actinopyga mauritiana* (James, 2000), *Actinopyga obese* (Ayotte, 2005), *Holothuria atra* (Stephenson and Campbell, 1960; Crosnier, 1962; Evans, 2016), *Holothuria scabra* (Caulier *et al.*, 2014), *Holothuria whitmaei* (Lyskin and Britayev, 2001; Evans, 2016), *Stichopus chloronotus* (Hoover, 1998; Lyskin and Britayev, 2004; Evans, 2016), *Thelenota ananas* (Caulier *et al.*, 2010; Evans, 2016), *Actinopyga echinites*, *Bohadschia argus*, *Holothuria fuscogilvaHolothuria isuga*, *Stichopus horrens*, *Thelenota anax* (Evans, 2016), *Thelenota ananas* (Woo *et al.,* 2014).

Geographical distribution: Recorded from Fiji (Dana, 1852; Evans, 2016),Madagascar (Caulier *et al.*, 2012, 2014; Evans, 2016), Maldives, Marshall Islands, Palau, Moorea Island, Society Islands, Philippines, W. Australia, Gulf of Tadjoura, Djibouti, Moorea Island, Society Islands Pacific Ocean, Hawaiian Islands Mayotte Island, Comoros Islands Caroline Islands, Fiji, Kenya; New Caledonia, Oman, Papua New Guinea, Tanzania, Vanuatu, Europa Island, Iles Eparses (Evans, 2016), Malaysia (Woo *et al.*, 2014). Records from Tamil Nadu (Kathirvel and Gokul 2010); Lakshadweep Islands (Alcock 1899;Sankarankuttyand Thomas,1963; Thomas 1969; Dev Roy and Nandi, 2015); Andaman Islands

(Kumaralingam *et al.,* 2013); Nicobar Islands (Nigam *et al*. Present study).

Remarks: Evans (2016) provided the detailed diagnosis of *Lissocarcinus orbicularis* fromIndo-West pacific region. *Lissocarcinus orbicularis* characterized by carapace without transverse, striated ridges, broader than long; anterolateral border with lobes, broad teeth, epibranchial ridges nearly absent or weakly to moderately developed. This species is beige to white and black to deep red patterned with white spots. Recently Evans (2016) have made molecular characterization of *Lissocarcinus orbicularis* collected from nine species of sea cucumber under the genera *Actinopyga, Bohadschia, Holothuria, Stichopus, Thelenota.* This species *Lissocarcinus orbicularis* closely resembles with *Lissocarcinus holothuricola*, but typically has a much smoother carapace and always exhibits lanceolate dactyli on the fifth pereopods (Evans, 2016). This genus consists of nine species, among only two species *viz*., *L.orbicularis* Dana, 1852, *L. holothuricula* (streets, 1877) ectosymbionts of holothurians (Stephenson, 1972; Spiridonov, 1990, Evans, 2016). Previously, *L. orbicularis* symbiotic crab was record on the host *Actinopyga mauritiana* from the Port Blair, Andaman Islands (James, 2000).

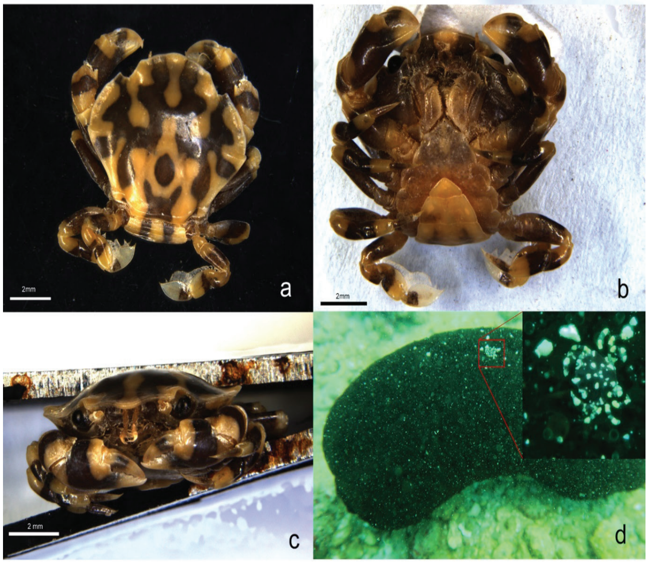


Figure 4: a-d. *Lissocarcinus orbicularis* Dana, 1852 (a. dorsal view, b. ventral view, c. frontal view, d. in-situ photo showing the host)

Acknowledgments

The authors are grateful to Dr. Kailash Chandra, Director, Zoological Survey of India, Kolkata, for providing facilities. The authors also thanks to the Department of Environment and Forests, Andaman and Nicobar Islands for their logistics support during the field survey in various parts of this archipelago.

References

Adams, A. & White, A. (1848). Crustacea. Part 1. pp. 1-32. In: The zoology of the voyage of H.M.S. *Samarang*, under the command of Captain Sir Edward Belcher, during the years 1843-1846, (Eds.) A. Adams, Benham & Reeve, London.

Adams, A. & White, A. (1849). Crustacea. Part 2. i-viii, pp. 33-67, pls 7-13. In: A. Adams (ed.), The zoology of the voyage of H.M.S. *Samarang* under the command of Captain Sir Edward Belcher, during the years 1843-1846, (Eds.) A. Adams, Benham & Reeve, London. (For dates of publication see Sherborn, C.D., 1922: cxi.)

Alcock, A. (1899) Materials for a carcinological fauna of India. No. 4. The Brachyura Cyclometopa. Part II. A revision of the Cyclometopa with an account of the families Portunidae, Cancridae and Corystidae. Journal of the Asiatic Society of Bengal, Calcutta, 68, 1–104.

Anonymous (1974). On zoological surveys of the South China Sea. Acta Zoologica Sinica 20: 113-130. [In Chinese.]

Ayotte, P. (2005). The Relationship Between Holothurians and the Portunid Crab *Lissocancinusorbicularis*. Unpublished Masters Thesis. University of Hawaii at Hilo.

Balss, H. (1922). Ostasiatische Decapoden III. Die Dromiaceen, Oxystomen und Parthenopiden. *Archiv für Naturgeschichte*, 88(3): 104-140. (In German)

Balss, H. (1924). Decapoden des Roten Meeres. III. Die Parthenopiden, Cyclo- und Catometopen. In: Expedition S.M. Schiff "Pola" in das Rote Meer, nördliche und südliche Hälfte 1895/96-1897/98.

Bouvier, E.L. & Seurat, G. (1905). *Eumedon convictor*, crabe commensal d'un oursin. *Compte R. Acad. Sci. Paris* 140: 629-631.

Castro, P. (1971). Nutritional aspects of the symbiosis between *Echinoecus pentagonus* and its host in Hawaii, Echinothrix calamaris. In: Aspects of the biology of symbiosis. T. C. Cheng, ed. Pp. 229-247. University Park Press, Baltimore, Maryland.

Castro, P. (1978). Settlement and habitat selection in the larvae of *Echinoecus pentagonus* (A. Milne Edwards), a brachyuran crab symbiotic with sea urchins. *Journal of Experimental Marine Biology and Ecology* 34: 259-270.

Castro, P. (1989). Range extensions and new host records of eumedonid crabs of the genus *Harrovia* Adams & White, 1848 (Decapoda, Brachyura, Eumedonidae). *Crustaceana* 57(1): 97-100.

Castro, P. (2015). Symbiotic Brachyura. p. 543–581. In: P. Castro, Davie, P.J.F., Guinot, D.,Schram, F.R. and Von Vaupel Klein, J.C. (eds) Decapoda: Brachyura, Treatise on Zoology– Anatomy, Taxonomy, Biology. The Crustacea, Complementary to the volumes translatedfrom the French of the Traité de Zoologie [founded by Grassé (†), P. P.], 9th edn. (C-I),Brill, Leiden and Boston.

Castro, P., Chia, D.G.B. & Ng, P.K.L. (1995). On the taxonomic status of *Ceratocarcinus longimanus* White, 1847 (Crustacea: Decapoda: Brachyura: Eumedonidae), a crab symbiotic with comatulid crinoids. *Raffles Bulletin Zool*ogy 43(1): 239-250.

Caulier, G., Lepoint, G., Nedervelde, F.V. and Eeckhaut, I. (2014). The diet of the Harlequin crab *Lissocarcinus orbicularis*, an obligate symbiont of sea cucumbers (holothuroids) belonging to the genera *Thelenota*, *Bohadschia* and *Holothuria.* Symbiosis. http://10.1007/s13199-014-0274-2

Caulier, G., Lepoint, G., Van Nedervelde, F. & Eeckhaut, I. (2012). Characterization of the Symbiotic Crab Lissocarcinus orbicularis (Dana, 1952) Population in Toliara Bay, Madagascar. In: Kroh, A. and Reich, M. (Eds.) Echinoderm Research 2010: Proceedings of the Seventh European Conference on Echinoderms, Göttingen, Germany, 2–9 October 2010. *Zoosymposia* 7: 177- 183

Caulier, G., Parmentier, E., Lepoint, G., Van Nedervelde, F. & Eeckhaut, I. (2010). Characterization of a population of the Harlequin crab, *Lissocarcinus orbicularis* Dana, 1852, an obligate symbiont of holothuroids. In Toliara bay (Madagascar). In: Kroh A & Reich M (eds.) Echinoderm Research 2010: Proceedings of the Seventh European Conference on Echinoderms, 10: 2-9.

Chen, H. (1975). Studies on the crabs of Xisha Islands, I. Guandong Provence, China. *Studia marina sinica*, 10: 157-179, figs 1-12, pls 1-3. (In Chinese with English summary.)

Chia, D.G.B. & Ng, P.K.L. (1998). A revision of *Ceratocarcinus* White, 1847, and *Harrovia* Adams & White, 1849 (Crustacea: Decapoda: Brachyura: Eumedonidae), two genera of crabs symbiotic with crinoids. *The Raffles Bulletin of Zoology* 46(2): 493-563, figs 1-33.

Chia, D.G.B., Castro, P. and Ng. P.K.L. (1999). Revision of the Genus *Echinoecus* (Decapoda: Brachyura: Eumedonidae), Crabs Symbiotic with Sea Urchins. *Journal of Crustacean Biology* 19 (4): 809-824.

Clark, A. H. (1950). Echinoderms from the Cocos-Keeling Islands. Bulletin of the Raffles Museum 22: 53-67.

Clark, A.M. and Rowe, F.W.E. (1971). Monograph of shallow-water Indo-west Pacific echinoderms. British Museum of Natural History, 238p.

Crosnier, A. (1962). Crustacés Décapodes Portunidae. *Faune de Madagascar* 16: 1-154.

Dai, A. & Yang, S. (1991). Crabs of the China Seas, i-iv, 1-608, figs 1-295, pls 1-74. China Ocean Press, Beijing and Springer-Verlag, Berlin Heidelberg New York Tokyo, English edition. (Translation from Chinese original 1986.)

Dai, A., Yang, S., Song, Y. and Chen, G. (1986). Crabs of the China seas. *China Ocean Press, Beijing, China*. 1-17, 1-642. [In Chinese.]

Dana, J.D. (1852). Crustacea. United States Exploring Expedition during the years 1838, 1839, 1840, 1841, 1842, under the command of Charles Wilkes, U.S.N., 13(pt. 1): i-viii, 1-685, pl. 8.

De Man, J.G. (1902). Die von Herrn Professor Kükenthal im indischen Archipel gesammelten Dekapoden und Stomatopoden. In: W. Kükenthal, Ergebnisse einer zoologischen Forschungsreise in den Molukken und Borneo, in Aufträge der Senckenberg. Naturforsch. Gesellschaft ausgeführt von Dr. Willy Kükenthal. *Abhandlungen der Senckenbergischen naturforschenden Gesellschaft* 25(3): 465-929, pls 19-27.

Dev Roy, M.K. & Nandi, N.C. (2012) Brachyuran crabs (Crustacea). In: Director ZSI, Kolkata (Ed.), Fauna of Andaman and Nicobar Islands. State Fauna Series. Vol. 19. Part 1. Zoological Survey of India, Kolkata, pp. 185–236.

Dev Roy, M.K. (2015) Conservation concerns on crustacean fauna of India. *Journal of Environment and Sociobiology* 12 (1), 77-98.

Estampador, E.P. (1937). A check list of Philippine crustacean decapods. *Philippine Journal of Science* 62(4): 465-559.

Evans, N.M. (2016). The systematics of Portunoidea Rafinesque, 1815, and the evolution of symbiotic swimming crabs. Ph.D. Thesis, University of Florida, 195p.

Fishelson, L. (1973). Ecology of the crinoids of the northern Red Sea with emphasis on epi- and endozoic fauna associated with them. *Journal of the marine biological Association of India* 15(2): 461-473, pls 1-2.

Flipse, H.J. (1930). Die Decapoda Brachyura der Siboga-Expedition. VI. Oxyrhyncha: *Parthenopidae. Siboga Expeditie Monografie*, 39 C2 (pt.6): 1-104, figs 1-44.

Fujita, Y. (2011). Complete larval development of crinoid-symbiotic crab, *Tiaramedon spinosum* (Miers, 1879) (Decapoda, Brachyura, Pilumnidae, Eumedoninae), described from laboratory-reared materials. Crustacean research 40: 57-73.

Garth, J.S. (1964). The Crustacea Decapoda (Brachyura and Anomura) of Eniwetok Atoll, Marshall Islands, with special reference to the obligate commensals of branching corals. Micronesica. *Journal of the College of Guam*, (*Guam, USA*) 1(1-2): 137-144, figs 1-2.

Gordon, I. (1934). Crustacea Brachyura. In: Résultats scientifique du voyage aux Indes Orientales Néerlandaises de LL. AA. RR. de Prince et la Princesse Léopold de Belgique. *Mémoires du Musée royal d'Histoire naturelle de Belgique, Hors-série* 3(15): 1-78, figs 1-37.

Gravier, C. (1922). Sur un nouveau crabe (Euymedonus Petiti nov. sp.) commensal d'un oursin de Tulear (Madagascar). *Bulletin de Museum National d'Histoire Naturelle* 28: 484-486.

Griffin, D.J.G. & Yaldwyn, J.C. (1968). The constitution, distribution and relationships of the Australian Decapod Crustacea. A preliminary review. *Proceedings of the Linnean Society of N.S.W.* 93(1): 164-183, 5 figs, 7 tables.

Holthuis, L.B. (1953). Enumeration of the decapod and stomatopod Crustacea from Pacific coral islands. *Atoll Research Bulletin* 24: 1-66.

Hoover, J.P. (1998). Hawaii Sea Creatures: A Guide to Hawaii's Marine Invertebrates. Honolulu, Mutual Publishing. 307p.

Hwang, J.-J. & Yu, H.-P. (1980). A fauna-list of the Crustacea from Lan-Yu Island. *Annual of Taiwan Museum* 23: 151-180. (in Chinese)

James, D.B. (2000). Sea Cucumber. In: Pillai, V.N. and Menon, N.G. (Eds). Marine Fisheries Research and Management. *Central of Marine Fisheries Research Institute, Kerala, India* pp. 138-139.

Jones, S. & Sankarankutty, C. (1961). Notes of animal associations. 3. A parthenopid crab, *Harrovia albolineata* Adams & White on a mariametrid crinoid, *Lamprometra* sp. *Journal of the marine biological Association of India* 2(2) (1960): 194-196.

Jose, S. & Kutty, R. (2020). A New Record of Symbiotic Crab (*Harrovia elegans* de Man, 1887) from the Gulf of Mannar, India. *Thalassas: An International Journal of Marine Sciences*https://doi.org/10.1007/s41208-020-00213-z.

Kathirvel, M. & Gokul, A. (2010) Checklist of brachyuran crabs from the Gulf of Mannar marine biosphere reserve. In: Technical Bulletin. Vol. 4. The Fisheries Technocrats Forum, Chennai, 45p.

Kim, H.S. & C.Y. Chang (1985). The brachyuran crabs of Cheju Island, Korea (Crustacea: Decapoda). *The Korean Journal of Systematic Zoology* 1(1-2): 41-60, figs 1-4.

Kim, H.S. & Rho, B.J. (1972). The seashore marine fauna of Chuja Islands, Korea. In: A report on the floral and faunal survey of Chuja islands, 1969: 67-108. (In Korean)

Kim, H.S. (1970). A checklist of the Anomura and Brachyura (Crustacea, Decapoda) of Korea. *Seoul University Journal, Biology and Agriculture* (*Series B*), 21: 1-34, fig. 1, pls 1-5.

Klunzinger, C.B. (1906). Die Spitz- und Spitzmundkrabben (Oxyrhyncha und Oxystomata) des Roten Meeres. Verlag von Ferdinand Enke, Stuttgart, Germany. Pp. vii+91.

Klunzinger, C.B. (1913). Die Rundkrabben (Cyclometopa) des Roten Meeres. Abhandlungen der kaiserlich Leop. Carol. *Deutschen Akademie der Naturforscher Halle*, 99(2): 97-402, figs 1-4, pls 5-11.

Kumaralingam, S., Raghunathan, C., Ajithkumar, T.T. & Kailash Chandra (2017) Reef associated common crustaceans of Andaman and Nicobar Islands, Lakshadweep and Gulf of Mannar, *Records of Zoological Survey of India, Occasional Paper* 380: 1-249.

Kumaralingam, S., Sivaperuman, C. & Raghunathan, C. (2013) Diversity and community structure of brachyuran crabs in North Andaman. pp. 171-181. In: Ecology and Conservation of Tropical Marine Faunal Communities. Part 1(Eds.) Venkataraman, K., Sivaperuman, C. & Raghunathan, C., Springer, Berlin and Heidelberg.

Laurie, R.D. (1906). Report on the Brachyura collected by Professor Herdman, at Ceylon, in 1902. In: W.A. Herdman, Report to the Government of Ceylon on the Pearl Oyster Fisheries of the Gulf of Mannar with supplementary reports upon the Marine Biology of Ceylon by other Naturalists, part 5, suppl. Rep. 40: 349-432, figs 1-12, pls 1-2.

Lyskin, S.A. & Britayev, T.A. (2001). An association of symbiotic crab *Lissocarcinus orbiculiaris*. International Crustacean Congress, Melbourne, Australia.

Lyskin, S.A. & Britayev, T.A. (2004). Symbionts of Holothurians from South Vietnam: Intra-and Interspecific Interactions. *Doklady Biological Sciences* 401: 116- 119.

Man, J.G., De (1887-1888). Report on the podophthalmous Crustacea of the Mergui Archipelago, collected for the trustees of the Indian Museum, Calcutta, by Dr. John Anderson, F.R.S., Superintendent of the Museum. J. Linn. Soc. (London), Zoology, 22(136): 1-64, pIs. 1-3 [Part I, 1887]; (137): 65-128, pIs. 4-8 [Part 11,18881: (138): 128-176, pIs. 9-12 [Part 111,18881; (139): 177-240, pIs. 13-15 [Part IV, 1888J; (140): 241-305, pIs. 16-19 [Part V. 1888].

Mariyambi, P.C., Mohammednoushad, B., Idreesbabu, K.K. & Sureshkumar, S. (2020). First record of two crinoid-associated brachyuran crabs (Crustacea: Decapoda: Pilumnidae) from the Arabian Sea, Western Indian Ocean. *Thalassas*https://doi.org/10.1007/s41208-020-00197-w.

Mather, P. & Bennett, I. (editors). (1984.) A coral reef handbook. A guide to the fauna, flora and geology of Heron Island and adjacent reefs and cays, second edition. *Australian Coral Reef Society, Brisbane, Australia*. Pp. 1-444. [Third edition published in 1993.]

Meher, B. & Thiruchitrambalam, G. (2019). A new distribution record of the Pentagonal Sea Urchin Crab *Echinoecus pentagonus* (A. Milne-Edwards, 1879) (Decapoda: Brachyura: Pilumnidae) from the Andaman Islands, India. *Journal of Threatened Taxa* 11(13): 14773–14776.

Miers, E.J. (1879). Descriptions of new or little-known species of Maioid Crustacea (Oxyrhyncha) in the collection of the British Museum. *Annals and Magazine of natural History*, (5) 4(19): 1-28, pls 4-5.

Miers, E.J. (1886). Report on the Brachyura collected by H.M.S. *Challenger* during the years 1873-1876. In: C.W. Thompson & J. Murray, Report on the Scientific Results of the exploring Voyage of H.M.S. *Challenger* during the years 1873-1876, under the command of Captain George S. Nares, R.N., F.R.S. and the Late Captain Frank Tourle Thomson, R.N., Zoology, 17(2): i-xli, 1-362, pls 1-29.

Milne Edwards, A. (1879). Description de quelques Crustaces nouveaux. *Bulletin de la Societe philomatique Paris* 7: 103-110.

Miyake, S. (1939). Note on crabs of the genus Echinoecus Rathbun living commensally with echinoids (Parthenopidae, Eumedoninae). *Annotationes Zoologicae Japonenses* 18: 83-94.

Monod, T. & Serène, R. (1976). Parasitic, commensal, and inquiline crustaceans collected during the Rumphius Expedition II. *Oseanologi di Indonesia* 6: 23-27.

Morrison, J.P.E. (1954). Ecological notes on the mollusks and other animals of Raroia. Animal ecology of Raroia Atoll, Tuomotus, part 1. *Atoll Research Bulletin* 34: 1-18.

Müller, F. (1887). Zur Crustaceen-fauna von Trincomali. *Verhandlungen der naturforschenden Gesellschaft in Basel* 8: 470-485, pls 4-5.

Nagai, S. & Nomura, K. (1988). Crustacea (Brachyura). [The guide book of marine organisms of Okinawa] 7: 1-250. Shinsei Tosho, Okinawa, Japan. [In Japanese.]

Ng, P.K.L. & Jeng, M.-S. (1999). The Brachyuran Crabs (Crustacea: Decapoda: Eumedonidae and Portunidae) Symbiotic with Echinoderms in Taiwan. *Zoological Studies* 38(3): 268-274.

Ng, P.K.L., Guinot, D. &Davie, P.J.F. (2008) Systema Brachyurorum: Part I. Anannotated checklist of extant brachyuran crabs of the world. *RafflesBulletin of Zoology Supplement* 17:1-286.

Nobili, G. (1907). Ricerche sui crostacei della Polinesia. Decapodi, stomatopodi, anisopodi e isopodi. *Memoire della Reale Accademia delle Scienze di Torino* (2)57: 351-430.

Prakash, S., Kumar, T.T.A. & Balasubramanian, T. (2012) Occurrence of Urchin crab *Echinoecuspentagonus* A. Milne Edwards, 1879 (Decapoda, Brachyura, Eumedonidae) in Lakshadweep Islands, India. *Proceedings of the Zoological Society*, *Kolkata* 65 (1): 61-63.

Rathbun, M.J. (1894). Notes on the crabs of the family Inachidae in the United States National Museum. *Proceedings of the United States National Museum* 17: 43-75.

Rathbun, M.J. (1906). The Brachyura and Macrura of the Hawaiian Islands. *Bulletin of the United States Fish Commission* 23(3): i-viii, 827-930, figs 1-79, pls 1-24.

Sakai, T. (1954). Preliminary report on the Brachyuran Crustacea of Hachijo Island. Records of Oceanographic Works in Japan, 1(2): 73-77.

Sakai, T. (1976). Crabs of Japan and the Adjacent Seas. (In 3 volumes: (1) English text: i-xxix, 1-773, figs 1-379, (2) Plates volume: 1-16, pls 1-251, (3) Japanese text: 1-461, figs 1-2, 3 maps.) Kodansha Ltd, Tokyo.

Sankarankutty, C. & Thomas, P.T. (1963). Some abnormalities in *Lissocarcinus orbicularis* Dana (Crustacea-Portunidae) from Minicoy. *Journal of the Marine Biological Association of India* 5(1): 144-145.

Sankarankutty, C. (1966). On Decapoda Brachyura from the Gulf of Mannar and Palk Bay. Proceedings of the Symposium on Crustacea Held at Ernakulam from January 12 to 15, 1965. *Marine biological Association of India, Symposium Series* 2(1): 347-362, pls 1-2.

Sastry, D.R.K. (1981). On some crustacean associates of Echinodermata from the Bay of Bengal. Records of the Zoological Survey of India 79: 19-30.

Serene, K. Romimohtarto, and M. K. Moosa. (1974). The Hippidea and Brachyura collected by the Rumphius Expedition I.-Oseanologi in Indonesia 1: 17-26.

Serène, R. & Vadon, C. (1981). Crustacés Décapodes: Brachyoures. Liste préliminaire, description de formes nouvelles et remarques taxonomiques. In: Résultats des Campagnes MUSORSTOM, 1. Philippines (18-28 mars 1976), vol. 1, no. 5. Mémoires ORSTOM, 91: 117-140, figs 1-3, pls 1-4. (In French with English summary).

Serène, R. (1968). The Brachyura of the Indo-West Pacific region. In: Prodromus for a check list of the non-planctonic marine fauna of South East Asia. UNESCO Singapore National Academy of Sciences, Special publication No. 1, Fauna IIIC3: 33-112.

Serène, R., Duc, T.V. & Luom, N.V. (1958). Eumedoninae du Viet-Nam (Crustacea). *Treubia* 24: 135-242, figs1-14, pls 4-7.

Serène, R., K. Romimohtarto & Moosa, M.K. (1976). The Hippidea, Stomatopoda and Brachyura collected by the Rumphius Expedition II. In: Report of the Rumphius Expedition II (January 15- February 8, 1975). Oseanologi di Indonesia, 6: 15-21.

Spiridonov, V.A. (1990). Results of the Rumphius Biohistorical Expedition to Ambon (1990): Part 8. Swimming Crabs of Ambon (Crustacea: Decapoda: Portunidae). *Zool. Med. Leiden* 73(4): 66-67.

Stephenson, W. & Campbell, B. (1960). The Australian Portinids (Crustacea: Portunidae): Remaining Genera. *Australian Journal of Marine and Freshwater Resources* 11: 73-112.

Stephenson, W. (1972). An annotated check list and key to the Indo-West-Pacific swimming crabs (Crustacea: Decapoda: Portunidae). *Bulletin of the Royal Society of New Zealand* 10: 1-64.

Stevcic, Z., Castro P. & Gore, R.H. (1988). Re-establishment of the Family Eumedonidae Dana, 1853 (Crustacea: Brachyura). *Journal of Natural History, London* 22: 1301-1324.

Thomas, M.M. (1969). Catalogue of crabs and hermit-crabs in the reference collections of the central marine fisheries research institute. *Bulletin of the Central Marine Fisheries Research Institute*, 7, 41-50.

Tikadar B.K. & Das A.K. (1985) Glimpses of animal life of Andaman and Nicobar Islands. Calcutta: Zoological Survey of India, pp. 170 & 178.

Tirmizi, N.M. & Kazmi, Q.B. (1982). Range extension of *Harrovia elegans* de Man, 1887, with a note on the male of *Dentoxanthus iranicus* Stephensen, 1945, from the northern Arabian Sea (Decapoda, Brachyura, Eumedoninae). *Crustaceana*, 43(3): 308-313.

Trivedi, J.N., Trivedi, D.J., Vachhrajani, K.D. & Ng, P.K.L. (2018) An annotated checklist of the marine brachyuran crabs (Crustacea: Decapoda: Brachyura) of India. *Zootaxa* 4502(1): 001-083.

Tweedie, M.W.F. (1950). The fauna of the Cocos-Keeling Islands, Brachyura and Stomatopoda. *Bulletin of the Raffles Museum* 22: 105-148.

Van Dover, C.L., Gore, R.H. & Castro, P. (1986). Echinoecus pentagonus (A. Milne Edwards, 1879): larval development and systematic position (Crustacea: Brachyura: Xanthoidea nec Parthenopidea). *Journal of Crustacean Biology* 6: 757-776.

White, A. (1847). List of the specimens of Decapoda Crustacea in the collection of the British Museum. London. *Trustees of British Museum* i-viii, 1-143.

Woo, S.P., Zulfigar, Y. and Tan, S.H. (2014). First record of *Lissocarcinus orbicularis* associated with sea cucumber, *Thelenota ananas*, in the north east of Celebes Sea. *Malayan Nature Journal*, 66(4), 368-375.

Yang, C.M. (1979). A list of the Brachyura in the Zoological reference collection of the Department of Zoology, University of Singapore. Guides Department of Zoology, National University of Singapore, 14: i-viii, 1-60.

Received : 2nd March 2020 Accepted : 4th May 2020

Significance of agro-forestry system for island ecosystem

R. Ravi[1]., N. Muthukumaran[2*] and Rajan Chellaiah[2]
[1]*Forest College and Research Institute, Mettupalayam, India*
[2]*Tamil Nadu Agricultural University, Coimbatore, India*
[*]*Corresponding author: nmuthu1980@gmail.com*

Abstract

The tropical islands are increasingly being affected by resource degradation and climate change posing serious challenge to the sustainability of the region and livelihood of the people. Trees play a predominant role in protecting and sustaining the productivity of coastal and island eco-regions either by agroforestry or as mangrove ecosystem. Agroforestry system involves the conscious and deliberate use of land for the concurrent production of agricultural crops including tree crops and shrubs/vines. There are different agroforestry models suitable for the region even in waterlogged and degraded areas. Mangroves are also important to coastal and island regions for a variety of reasons, including aquaculture, agriculture, forestry, protection against shoreline erosion, as a source of fire-wood and building material, and other local subsistence use.

Keywords: Tropical Island, tree species, land degradation, conservation, livelihood

Introduction

The burgeoning population and climate change have emerged as a seriously challenge to the survival and sustainability of several tropical islands resulting in natural disasters, natural resource degradation, poverty, loss of traditional culture and the detrimental effects of invasive species (IPCC, 2007). The irreversible loss of biodiversity (CBD, 2006) and other adverse impacts necessitate identification of strategies of sustainable utilization and enhancing resilience against climate change. In the Indian tropical islands of Andaman and Nicobar, around 15% of cultivated land lies within the coastal low-lying ecosystems with elevation of <20 m above mean sea level. These regions face twin problems of water logging during monsoon season and water scarcity for irrigation during the post-monsoon season (Velmurugan et al., 2016). Soils are prone to poor drainage, acid/saline conditions caused by rapid salt imbalance, and sea water intrusion during the periods of high tide (Velmurugan et al., 2014a).

The coastal region is generally mono-cropped with rice (Oryza sativa), and have low productivity with severe consequences to the livelihood of coastal population. Further, the December 2004 Indian Ocean tsunami severely impacted coastal regions of Indian Ocean, and highlighted vulnerability to extreme events (Willroth et al., 2012). Therefore, adoption of appropriate land management strategy is essential to manage land and water resources of the region also of those prone to sea level rise in a changing climate (Cruz et al., 2007). Land shaping methods are proposed as a viable option for agricultural area affected by salinity and waterlogging (Velmurugan et al., 2015a, b). In this context, tree species in agroforestry or mangrove ecosystem play a predominant role in protecting and sustaining the productivity of island eco-regions. In this article we provide some insight into how different tree species can be used to address this challenge through different agroforestry systems.

Agroforestry models for island eco-region

Agroforestry is a collective name for a land-use system and technology whereby woody perennials are deliberately used on the same land management unit as agricultural crops and/or animals in some form of spatial arrangement or temporal sequence. In an agroforestry system there are both ecological and economical interactions between various components (Lundgren and Raintree, 1983). Based on the nature of components, agroforestry systems can be classified into agri-silvicultural systems, silvipastoral systems and Agrisilvipastoral systems.

Although these systems are conceptually well distinguished but in island ecosystem they often exist in interspersed form. They are more valuable in maintaining the agro-ecosystem balance and adaptable in problem soils as in the case of waterlogged or saline soils than any other cultivated plants. Based on the purpose and land conditions suitable system is selected but more often agri-silvicultural system is practised. This is known to enhance farm income and provides ecological services (Dagar, 1995). Some of the tree species suitable for problem soils grown under different agroforestry models are given in table 1. The details are described in the following sections.

Multipurpose tree species garden

It is most important agroforestry model, practised by the tribals in Nicobar Islands, in which various kinds of tree species are grown mixed without any specific design. The major function of this system is production of food, fodder and wood products for home consumption and commercial purpose. Major woody species used in this system are *Areca catechu, Phoenix dactilifera, Artocarpus spp., Cocos nucifera, Mangifera indica, Syzygium aromaticum* etc. In Nicobar Islands fruit trees are included in the multipurpose tree gardens which are mostly evergreen or moist deciduous type (Fig. 1). This is practised as rainfed systems in undulated inland terrain and in coastal areas. Unlike annual crops majority of the tree species included in the model can be grown even in saline areas with little care. The system is much more stable than growing only annual crops but it lacks specialization.

Fig. 1 Multipurpose tree garden in the tribal areas of Car Nicobar, India

Coconut as a base crop provides lots of organic wastes which can be composted effectively and recycled to supply plant nutrients and improve the soil conditions (Swarnam and Velmurugan, 2014). This also helps in organic matter addition and water conservation which sustain the production system.

Agri-silvi-pastoral system

Another important agroforestry measure suitable for island conditions is growing multipurpose tree species along with grasses or seasonal crops. The climatic conditions and physiography of Andaman and Nicobar and other tropical Islands offer ample scope for growing fodder trees, shrubs and grasses together in silvipastoral system with appropriate silvicultural management (Jaisankar et al., 2014). Silvopastoralism is one such agroforestry practice that intentionally integrates trees, forage crops, and livestock into a structural practice of planned interactions (Clason and Sharrow, 2000). The primary role of this system is production of green fodder to support the livestock production on a sustainable basis without much constraint on soil resources and environmental degradation. Some of the suitable multipurpose trees employed in agroforestry are *Leucaena leucocephala, Acacia albida, Cassia siamea, Casuarina equisetifolia, Azadirachta indica, Acacia Senegal and Cocos nucifera*. Apart from this some of the tree species like *Tamarix, Prosopis, Salvadora, Acacia farnesiana, Casuarina (glauca, obesa, equiselifolia), Acacia tortilis, A. nilotica, Pongamia pinnata, Albizia lebbeck, Ziziphus mauritiana, Parkinsonia aculeata etc.* can also be grown in saline soils (Dagar, 1995). This system also supports organic farming in the island, by enriching the soil with organic matter, nutrients and providing space to accommodate spice crops (Velmurugan et al., 2014b).

Tree borne oil seeds

It was observed that Andaman and Nicobar Islands have wide diversity of tree borne oil seeds (TBO's) with high oil content and adaptability to marginal and coastal areas. A study conducted in these islands revealed that Jatropha is one of the most important species which are widely distributed with varying amount of oil viz., *J. curcas* (37 %), *J. gossypifolia* (40 %) and *J. podagrica*

(35 %). Apart from this, *Aphanomixis polystachya* (38 %)*, Calophyllum inophyllum* (51 %)*, Pongamia pinnata* (36 %), *Sapium baccatum* (49 %) and *Simaruba glauca* (53 %) were other potential oil yielding TBO's (Jaisankar *et al*., 2015). In Nicobar group of Islands *Calophyllum soulattri (49%)* was identified as a potential TBO which are traditionally used by the tribals. There is a wide biodiversity of these TBO's which has the potential to be exploited commercially grown on saline, and other degraded lands in a mixed stand or along with shelter belts in an island ecosystem.

Table 1: Suitable trees and grasses for various problem sites

Strees condition	Suitable trees/ shrubs	Grasses
Deep sandy soils	*Acacia aneura, A. tortilis, Ailanthus excels, Albizia lebbeck, Azadirachta indica, Cassia siamea, Eucalyptus camaldulensis, E. melanophloia, E. terminalis,*	*Cenchrus ciliaris, Dichanthium annulatum and Panicum antidotale*
Sandy and rocky	*Acacia. senegal, A. tortilis, Agave spp. Azadirachta indica, Butea monosperma, Cassia siamea, P. chilensis*	*Cenchrus ciliaris, C. setigerus*
Very High salinity (Ece > 35 dS/m	*Hibiscus Pongamia pinnata, Desmodium umbellatum, Barringtonia asiatica, Manilkara littoralis*	
High salt tolerant (Ece 25-35)	*Casuarina, Thespesia populnea and Cocos nucifera (on specific sites)*	
Tolerant (Ece 15-25)	*Casuarina sp., , Pongamia pinnata, Eucalyptus camaldulensis, Albizia lebbeck, Ziziphus mauritiana, Parkinsonia aculeata*	
Moderately tolerant (Ece 10-15)	*Casuarina Azadirachta indica, Dendrocalamus strictus, Butea monosperma, Leucaena leucocephala, Tamarindus indica, Balanites roxburghii,*	

Alley Cropping (Hedgerow Intercropping)

Alley cropping, which is typically regarded as the inter-cropping of trees and crops simultaneously, are mostly characterized by systems which inter-crop valuable nut and hardwood trees with cash crops using widely spaced rows between trees for planting crops. Some of them are given in the table 2.

Table 2: Tree species and Crops suitable for Agroforestry system

State	Tree crop	Associated agricultural crops
Mainland (India)	*Anacardium occidentale (Cashew)*	Hill paddy, groundnut, sweet potato
	Tectona grandis *Bombax ceiba* *Eucalyptus spp.*	Paddy, tapioca, ginger, turmeric
	Tectona grandis, Bamboo *Santalum album* *Tamarindus indica* *Acacia nilotica*	Millet, pulses, groundnut, cotton

	Acacia mearnsii	
	Ceiba pentandra	
	Cashew, Rubber	
Andaman and Nicobar Islands	*Pterocarpus dalbergioides*	Paddy, Vegetables and Tuber crops
	Coconut	Pineapple, Amaranthus, tubers
	Arecanut	
	Gliricedia sepium	
	Jack fruit	

It consisting of closer spaced tree rows typically planted with fast growing multipurpose trees which are often nitrogen fixing and provide secondary products such as fodder, fuel wood or mulch (Fig. 2). Furthermore, the deep roots of trees appear to minimize below-ground competition with crops, enabling these systems to be agro-ecologically sound and economically viable. Compared to conventional mono-cropping systems, alley cropping systems may prove to be more sustainable and profitable. Alley cropping practices appear to be a rational alternative land use for improving agricultural sustainability while at the same time being economically viable.

Fig. 2: Maize is grown in the alley formed by Gliricidia

Bio-shield along the coastal areas

Coastal vegetation has been widely recognized as a natural barrier for reducing the energy of storm surges and tsunami waves. After studying the impact of tsunami on coastal communities Kathiresan and Rajendran (2005) concluded that the presence of mangroves reduced the human death toll along the Tamil Nadu coast of southeast India. Guebas *et al*., (2005) showed by cluster analysis that the man-made structures located directly behind the most extensive mangroves were less damaged. Field surveys in Sri Lanka and Thailand after the Indian Ocean tsunami of 2004 showed that older *casurina* belts on the coast withstood the tsunami but failed to provide good protection because tree growth, forest type and density have significant effect on reducing the tsunami wave impact. Pandanus having wide diversity is also very much suitable in the coastal and island region as bioshield component (Jaisankar et al., 2020). The evidences suggest that vegetation barrier alone cannot completely stop a tsunami or storm surge and its effectiveness depends on the magnitude of the storm surge as well as the structure of the vegetation (Tanaka *et al*., 2007).

Based on the field level evaluation mangrove based vegetation barrier in the coastal area is proposed by several researchers as a best bioshield model against the sea surges and like events. The crown and stem of mangroves serve as physical barriers while the entangled root masses of mangroves dissipate the wave energy and guard the coastlines. Hence this is often referred to as bioshield or natural sea defense (Fig. 3). The specialized roots of mangroves trap and hold sediments and siltation from the uplands. Mangroves played a protective role in saving the lives of coastal dwellers in Andaman Islands by taking the brunt of destructive waves during the giant tsunami waves which struck the Indian Ocean region in 2004. Much of the ecological services of mangroves lie in protecting the coast from solar UV-B radiation, fury of cyclones, sea level rise, coastal erosion and other natural threats in the coastline. The bioshield also minimizes the effect of sea water intrusion and erosion in the agricultural land located behind the shield. Therefore, establishment of mangrove based shield in the sea front of the coastal and islands should be an ideal choice to protect them from sea surges and tsunami like incidents in the future.

Fig. 3. Bio-shield protects against the sea surges and storms

Biodrainage

Introduction of canal irrigation without provision of adequate drainage causes rise in ground water table leading to waterlogging due to seepage and secondary salinization. In India, the total degraded land due to waterlogging is 6.41 M ha. As sub-surface drainage is costly and disposal of effluents has inherited environmental problems, a viable alternative is biodrainage, which is 'pumping of excess soil water by deep-rooted plants using bioenergy'. The impact of block plantations of *Eucalyptus tereticornis* was tested and found effective in reducing the ground water level. In an experiment it was observed that the ground water table underneath the strip plantations was 0.85m during a period of 3 years and it reached below 2m after 5 years. The average above ground oven dry biomass of 5 ½ years old strip plantation was 99.9 kg tree^{-1} resulting in 24.0 t ha^{-1} above ground biomass of 240 surviving trees. The average below ground oven dry biomass of roots was 8.9t ha^{-1} and the total oven dry biomass was 32.6t ha^{-1}. The carbon in the oven dry biomass was 15.5t ha^{-1}. The average transpiration rate (measured by sap flow) of ground water by these plantations ranged from (litres day^{-1} tree^{-1}) 44.5 – 56.3 in May to 14.8 – 16.2 in January. The annual transpiration rate was equal to 268 mm per annum. The farmers can ear INR 72000 ha^{-1} at a rotation of 5 years and 4 months resulting in a benefit-cost ratio of 3.5:1.

Conclusion

Tree species involving agroforestry system are indispensable component of management and restoration of island region affected by land degradation. Similarly it also provides gainful employment opportunities and enhances the productivity of farm land. There is an imperative need to formulate proper restoration practices for mangrove plantation in degraded coastal areas and conservation of existing stand to protect the coast against the sea surges and tides. Fast growing species such as *Avicennia* and *Sonneratia* can be utilized to establish the mangrove stand. The management plan should include afforestation, regeneration of degraded mangrove areas, protective measures and eco-development.

References

CBD, (2006). Global biodiversity outlook 2. Convention on Biological Diversity. UNEP, Montreal, pp. 81.

Clason T.R. & Sharrow, S.H. (2000). Silvopastoral practices. In: H.E. Garrett, W.J. Rietveld and R.F. Fisher (Eds.). North American Agroforestry: An Integrated Science and Practice. *American Society of Agronomy*, Madison, WI. 119-147.

Cruz, R.V., Harasawa, H., Lal, M., Wu, S., Anokhin, Y., Punsalmaa, B., Honda, Y., Jafari, M., Li, C. & Huu Ninh, N., (2007). Asia Climate Change 2007: impacts, adaptation and vulnerability. Contribution of working group II. In: Parry, M.L. (Ed.), Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, pp. 469–506.

Dagar, J.C., (1995). Agroforestry systems for the Andaman and Nicobar Islands, *International Tree Crops Journal*, **8(2-3)**:107-128.

Guebas, F.D., Jayatissa, L.P., Di Nitto, D., Bosire, J.O., Lo Seen, D. & Koedam, N. (2005). "How effective were mangroves as a defence against the recent tsunami?" *Current Biology* **15(12)**:443–447.

IPCC, (2007). Climate Change 2007: Synthesis Report, Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Geneva, Switzerland, pp. 104.

Jaisankar, I., Augustine Jerard, B., Velmurugan, A. & Swarnam, T.P. (2020). Analysis of genetic relationship of Pandanus tectorius accessions of Andaman and Nicobar Islands using RAPD and ISSR markers. Indian J. of Agroforestry 22(1): 24-30

Jaisankar, I., Swarnam, T.P., Singh, D.R. & Velmurugan, A. (2014). Identification, evaluation and development of silvipastoral System for bay island condition. Journal of international academic research for multidisciplinary. 2(7):501-510.

Jaisankar, I., Velmurugan, A., Swarnam, T.P. & Dam Roy, S. (2015). Diversity of tree borne oil seeds in Andaman and Nicobar Islands. In: Dam Roy et al., (Eds.), Extended summaries of National Seminar on Harmonizing Biodiversity and Climate Change: Challenges & Opportunity, 17-19th April, CIARI, Port Blair, pp-38.

Kathiresan, K. & Rajendran, N. (2005). Coastal mangrove forests mitigated tsunami, *Estuarine Coast Shelf Science* **65(3)**:601– 606.

Lundgren, B.O. & Raintree, J.B. (1982). Sustained agroforestry. In: B. Nestel, ed. Agricultural research for development: potentials and challenges in Asia, pp. 37–49. The Hague, International Service for National Agricultural Research.

Swarnam. P. & Velmurugan, A. (2014). Evaluation of Coconut Wastes as an Amendment to Acidic Soils in Low-Input Agricultural System Communications in Soil Science and Plant Analysis, 45:1–12.

Tanaka, N. (2007). Coastal vegetation structures and their functions in tsunami protection: experience of the recent Indian Ocean tsunami. *Landscape and Ecological Engineering*, **3**:33–45.

Velmurugan, A., Swarnam, T.P. Ambast, S.K. & Kumar, N. (2016). Managing waterlogging and soil salinity with a permanent raised bed and furrow system in coastal lowlands of humid tropics, Agricultural Water Management 168: 56–67

Velmurugan, A., Swarnam, T.P., Ambast, S.K., Meena, R.L. & Subramani, T. (2015a). Soil Salinity Dynamics in Raised Bed and Furrow (RBF) System and its Effect on Alleviating Waterlogging in the Coastal Lowlands. Journal of Soil Salinity and Water Quality, 7(2): 90-97.

Velmurugan, A., Swarnam, T.P., Ambast, S.K., Ravisankar, N. & Subramani, T. (2014a). Land degradation and its spatio-temporal changes induced by natural events in Andaman islands, Journal of the Andaman Science Association, 19(1):65-74.

Velmurugan, A., Swarnam, T.P., Ravisankar, N. & Dam Roy, S. (2014b). Prospects for organic farming in Andaman and Nicobar Islands. *Journal of the Andaman Science Association* **19(2)**:1-4.

Velmurugan, A., T.P.Swarnam & Rattan Lal, (2015b). Effect of land shaping on soil properties and crop yield in tsunami inundated coastal soils of Southern Andaman Island. Agriculture, Ecosystems and Environment 206, 1-9.

Willroth, P., Massmann, F., Wehrhahn, R., Revilla Diez, J., (2012). Socio-economic vulnerability of coastal communities in southern Thailand: the development of adaptation strategies. Nat. Hazards Earth Syst. Sci. 12, 2647–2658. doi:http://dx. doi.org/10.5194/nhess-12-2647-2012.

Received : 6th January 2020 Accepted : 20th May 2020

The probable origin of SARS-CoV-2: A Scientific report

[1]*A. Russel, M. [1]Holmes and [2]P. Lim
[1]*Westmead Hospital, Westmead, NSW, Australia.* [2]*Tan Tock Seng Hospital, Singapore.*
*Corresponding author:** *russelbioau@gmail.com*

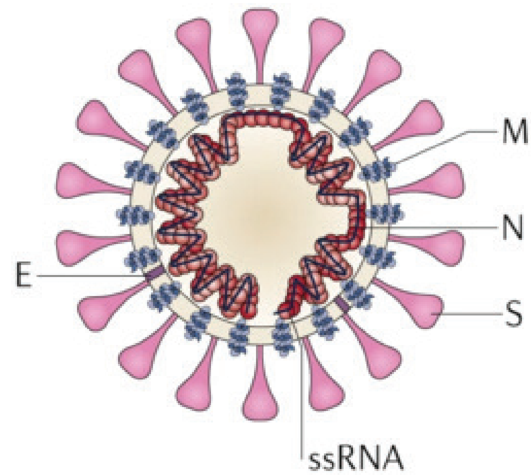
Introduction

The novel SARS-CoV-2, called corona virus that emerged in the city of Wuhan, China in December 2019, has since caused extraordinary scale COVID-19 epidemic, and spread to almost the entire world. On December 31st 2019, World Health Organization was alerted by China, of an outbreak of a novel strain of corona virus causing severe illness, which was subsequently named SARS-CoV-2. Worldwide it has infected more than a billion people, caused death ranging from 1-5% of the infected population and still on the rise. The killer virus (highly infectious and capable of causing death) is seen as a threat to human civilization and survival that challenges humans' ability to detect, understand and manage the unprecedented pandemic pathogen. This generated worldwide debate on its origin, molecular nature, mode of spread, and infectious behaviour inside the human body.

Corona viruses are a large family of viruses that can cause illnesses ranging widely in severity (Fig. 1). The first known severe illness caused by a corona virus emerged with the 2003 Severe Acute Respiratory Syndrome (SARS) epidemic in China (Andersen et al., 2020). A second outbreak of severe illness began in 2012 in Saudi Arabia with the Middle East Respiratory Syndrome (MERS).

Source of data

After the epidemic began in Wuhen, China, at first scientists from China sequenced the genome of SARS-CoV-2 and made the data available to researchers worldwide in public domain. After detection of the SARS-CoV-2 epidemic the number of COVID-19 cases has been increasing because of human to human transmission after a single introduction into the human population. Researchers have used this sequencing data to explore the origins and evolution of SARS-CoV-2 by focusing in on several tell-tale features of the virus (Wan et al., 2020; Letko et al., 2020). The scientists analyzed the genetic template for spike proteins, armatures on the outside of the virus that it uses to grab and penetrate the outer walls of human and animal cells. More specifically, they focused on two important features of the spike protein: the receptor-binding domain (RBD), a kind of grappling hook that grips onto host cells, and the cleavage site, a molecular can opener that allows the virus to crack open and enter host cells (Andersen et al., 2020).



The 3' terminus encodes structural proteins, including envelope glycoproteins spike (S), envelope (E), membrane (M) and nucleocapsid (N)

Fig. 1: Corona viruses form enveloped and spherical particles of 100–160 nm in diameter

Evidence for natural evolution

After detailed analysis scientists found that the RBD portion of the SARS-CoV-2 spike proteins had evolved to effectively target a molecular feature on the outside of human cells called ACE2, a receptor involved in regulating blood pressure. The SARS-CoV-2 spike protein was so effective at binding the human cells, in fact, that the scientists believe that it was the probably or as a result of natural selection and not the product of genetic engineering.

This evidence for natural evolution was supported by data on SARS-CoV-2's overall molecular structure. If someone were seeking to engineer a new corona virus as a pathogen, they would have constructed it from the backbone of a virus known to cause illness. But the scientists found that the SARS-CoV-2 backbone differed substantially from those of already known corona viruses and mostly resembled related viruses found in bats and pangolins. These two features of the virus, the mutations in the RBD portion of the spike protein and its distinct backbone, rules out laboratory manipulation as a potential origin for SARS-CoV-2 (Andersen et al., 2020). These findings are crucially important to bring an evidence-based view to the rumors that have been circulating about the origins of the virus (SARS-CoV-2) causing COVID-19. Thus it can be concluded that the virus is the product of natural evolution not deliberate genetic engineering.

Possible origins of the virus

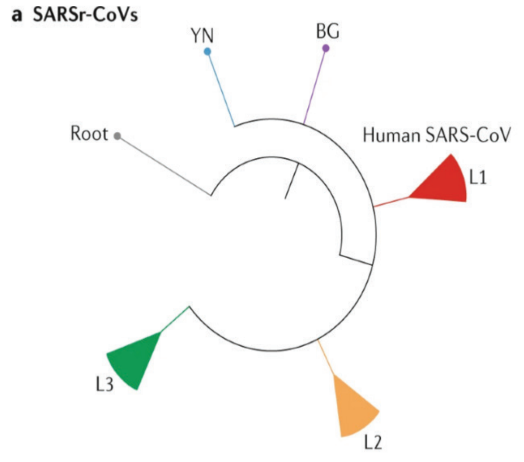
It is observed that the RBD of SARS-CoV-2 is optimized for binding to human ACE2 with an efficient solution different from those previously predicted virus (Wan et al., 2020; Letko et al., 2020). If genetic manipulation had been performed, it would have been easy to use one of the several reverse-genetic systems available for beta corona viruses (Cui et al., 2019). However, the genetic data conclusively show that SARS-CoV-2 is not derived from any previously used virus backbone. There could be two scenarios that can plausibly explain the origin of SARS-CoV-2: (i) natural selection in an animal host before zoonotic transfer; and (ii) natural selection in humans following zoonotic transfer.

In one scenario, the virus evolved to its current pathogenic state through natural selection in a non-human host and then jumped to humans. This is how previous corona virus outbreaks have emerged, with humans contracting the virus after direct exposure to civets (SARS) and camels (MERS). The researchers proposed bats as the most likely reservoir for SARS-CoV-2 as it is very similar to a bat corona virus (Zhou et al., 2020). There are no documented cases of direct bat-human transmission, however, suggesting that an intermediate host was likely involved between bats and humans.

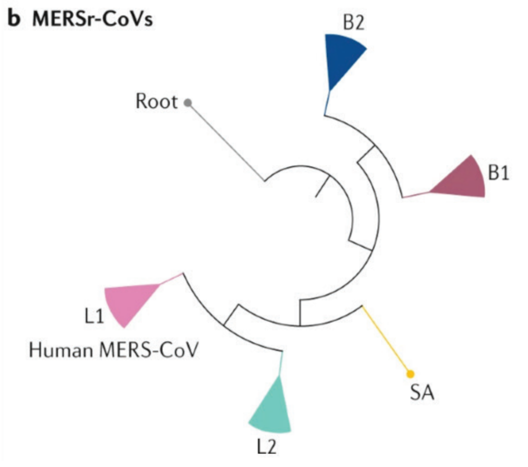
In this scenario, both of the distinctive features of SARS-CoV-2's spike protein the RBD portion that binds to cells and the cleavage site that opens the virus up would have evolved to their current state prior to entering humans. In this case, the current epidemic would probably have emerged rapidly as soon as humans were infected, as the virus would have already evolved the features that make it pathogenic and able to spread between people.

In the other proposed scenario, a non-pathogenic version of the virus jumped from an animal host into humans and then evolved to its current pathogenic state within the human population. For instance, some corona viruses from pangolins, armadillo-like mammals found in Asia and Africa, have an RBD structure very similar to that of SARS-CoV-2 (Zhang et al., 2020). A corona virus from a pangolin could possibly have been transmitted to a human, either directly or through an intermediary host such as civets or ferrets. Then the other distinct spike protein characteristic of SARS-CoV-2, the cleavage site, could have evolved within a human host, possibly via limited undetected circulation in the human population prior to the beginning of the epidemic. The researchers found that the SARS-CoV-2 cleavage site, appears similar to the cleavage sites of strains of bird flu that has been shown to transmit easily between people. SARS-CoV-2 could have evolved such a virulent cleavage site in human cells and soon kicked off the current epidemic, as the corona virus would possibly have become far more capable of spreading between people.

On the other hand, it needs to be recorded that basic research involving passage of bat SARS-CoV-like coronaviruses in cell culture and/or animal models has been ongoing for many years in biosafety level 2 laboratories across the world and there are documented instances of laboratory escapes of SARS-CoV (Lim et al., 2004). Therefore, it is utmost necessary to examine the possibility of an inadvertent laboratory release of SARS-CoV-2. In theory, it is possible that SARS-CoV-2 acquired RBD mutations during adaptation to passage in cell culture, as has been observed in studies of SARS-CoV (Sheahan, et al., 2008). The finding of SARS-CoV-like corona viruses from pangolins with nearly identical RBDs, however, provides a much stronger and more parsimonious explanation of how SARS-CoV-2 acquired these via recombination or mutation (Cui et al., 2019).



The figure shows a simplified phylogenetic tree of severe acute respiratory syndrome-related corona viruses (SARSr-CoVs) from bats. SARSr-CoVs cluster into three lineages, L1–L3, and human severe acute respiratory syndrome corona viruses (SARS-CoVs) embed in L1. Two individual SARSr-CoVs do not cluster into these lineages



Middle East respiratory syndrome-related corona viruses (MERSr-CoVs) form two major viral lineages, L1 and L2. L1 is found in humans and camels, and L2 is found only in camels. Two small clusters, B1 (bat 1) and B2, and one single virus, SA, from South Africa, were found in bats.

(Source : Cui et al., 2019)

Fig. 2: Phylogenetic analysis of SARSr-CoVs and MERSr-CoVs

If the SARS-CoV-2 entered humans in its current pathogenic form from an animal source, it raises the probability of future outbreaks, as the illness-causing strain of the virus could still be circulating in the animal population and might once again jump into humans. The chances are lower of a non-pathogenic corona virus entering the human population and then evolving properties similar to SARS-CoV-2.

Treatment

There is no specific treatment for disease caused by a novel corona virus. However, many of the symptoms can be treated and therefore treatment based on the patient's clinical condition. While some western, traditional or home remedies may provide comfort and alleviate symptoms of mild COVID-19, there are no medicines that have been shown to prevent or cure the disease. WHO does not recommend self-medication with any medicines, including antibiotics, as a prevention or cure for COVID-19. There is no strong evidence that the Bacille Calmette-Guérin vaccine (BCG) protects people against infection with COVID-19 virus. Two clinical trials addressing this question are underway meanwhile WHO continues to recommend neonatal BCG vaccination in countries or settings with a high incidence of tuberculosis.

Most people (about 80%) recover from the disease without needing special treatment and some other with symptoms are treated systematically for which protocols are developed. Around 1 in every 5 people who are infected with COVID-19 develops difficulty in breathing and requires hospital care. People who are aged over 60 years and people who have underlying medical conditions such as diabetes, heart disease, respiratory disease or hypertension are among those who are at greater risk.

Conclusions

The entire world is now focused on how to bring down the human casualty to COVID-19 curtailment of its further spread to non-infected population through all possible measures. Given the level of damage it has caused to the human life in the modern day, it is not surprising to see the active involvement of scientists from various institutions across the globe trying to design a vaccine and complete the required test as early as possible to bring the vaccine to the public use. At this juncture, detailed understanding of how an animal virus jumped species boundaries to infect humans so productively will help in the prevention of future zoonotic events. In addition, identifying the closest viral relatives of SARS-CoV-2 circulating in animals will greatly support studies of viral function. Indeed, the availability of the RaTG13 bat sequence helped to unlock the RBD mutations and the polybasic cleavage site.

Based on the observations of available information on SARS-CoV-2 features, including the optimized RBD and polybasic cleavage site, it is unlikely that SARS-CoV-2 is a purposefully manipulated virus in laboratories. However it is currently impossible to prove or disprove the other theories of its origin described here. More scientific data could swing the balance of evidence to favor one hypothesis over another.

References

Andersen, K.G., Rambaut, A., Lipkin, W.I. et al. (2020). The proximal origin of SARS-CoV-2. Nat Med 26, 450–452. https://doi.org/10.1038/s41591-020-0820-9

Cui, J., Li, F. & Shi, Z. (2019). Origin and evolution of pathogenic corona viruses. Nat Rev Microbiol17, 181–192. https://doi.org/10.1038/s41579-018-0118-9

Letko, M., Marzi, A. & Munster, V. (2020). Nat. Microbiol. https://doi.org/10.1038/s41564-020-0688-y

Lim, P.L., Asok Kurup, Gopalakrishna, G., Chan, K.P., et al., (2004). Laboratory-acquired severe acute respiratory syndrome. N. Engl. J. Med. 350, 1740–1745.

Sheahan, T., Rockx, B., Donaldson, E., Sims, A., Pickles, R., Corti, D. & Ralph Baric (2008). Mechanisms of Zoonotic Severe Acute Respiratory Syndrome Coronavirus Host Range Expansion in Human Airway Epithelium. J. Virol. 82, 2274–2285.

Wan, Y., Shang, J., Graham, R., Baric, R. S. & Li, F. J. (2020). Virol. https://doi.org/10.1128/JVI.00127-20

Zhang, T., Wu, Q. & Zhang, Z. (2020). Pangolin homology associated with 2019-nCoV. bioRxiv https://doi.org/10.1101/2020.02.19.950253.

Zhou, P., Yang, X., Wang, X. et al. (2020). A pneumonia outbreak associated with a new coronavirus of probable bat origin. Nature 579, 270–273. https://doi.org/ 10.1038/s41586-020-2012-7

Received : Accepted : --------------

Andaman Science Association (Regd. 544)

HQ C/o Central Agricultural Research Institute (CARI)
Garacharma, Port Blair -744 105, (Andaman and Nicobar Island)
Email : andamanscience84@gmail.com, asa_portblair@yahoo.com

MEMBERSHIP APPLICATION FORM

Affix passport size photograph

The General Secretary,
Andaman Science Association
HQ: C/o ICAR - Central Island Agricultural Research Institute
Port Blair -744101 (A & N Islands) India

Dear Sir,

I am sending herewith the sum of Rupees ……………………… (Rs……………………………) by cash/ B.D./ Cheque No………………………….. dated………………… of .... (Name of the Bank) being my subscription as a **life/ annual** member of the **Andaman Science Association** from the year .... Please enrol my name as a member of the society.

Kindly acknowledge the receipt and membership.

Yours faithfully

Signature: ________________________

Full Name: ________________________

Date: …………….

(Please strike ✓ in the appropriate Box)

Individual Membership

Annual Membership ☐

Life Membership ☐

Institutional/ Organizational Membership

Ordinary Membership ☐

Corporate Membership ☐

Membership No.: ASA / 20___/

Personal Details:

(Please fill up the Form in BLOCK LETTERS)

Name in full : **Dr/ Shri/ Smt.** ______________________________

Designation : ______________________________

Field of specialization : ______________________________

Address for communication : ______________________________

____

____

Permanent Address : ______________________________

____

____

Telephone : (+91) ____________________ Fax: (+91) ________________

Mobile No. : (+91) __________________ **e-mail** :________________________

Subscription Rates

Individual Annual Members:	Indian Nationals	NRI & Foreign National
Admission fee	: Rs.100/-	USD 05/-
Annual Subscription	: Rs.800/-	USD 20/-
Individual Life Members	: Rs.4000/-	USD 100/-
Student Membership	: Rs.700 (Annual)	--
Institutions & Libraries Members:		
Annual Members	: Rs. 3000/- per year	--
Corporate/Institutional Membership	: Rs. 30000/- at a time	--

Note: Subscription should be sent by ***Cash/ /Bank Draft/ Multicity Cheques*** addressed to the **General Secretary, Andaman Science Association, Post ICAR-Central Island Agricultural Research Institute, Port Blair – 744 101 (A & N Islands)** in the form of Bank Drafts/ Multicity Cheques should be drawn on the S.B.I., Garacharma Branch in favour of "Andaman Science Association" Multicity Cheques will be accepted only.