Indian J Anim Health (2025)
DOI: https://doi.org/10.36062/ijah.2025.05325

Research Article

Differences in electrocardiographic responses of young and adult Indian sloth bears *(Melursus ursinus)* to ketamine-xylazine anesthetic combination

S. Mohapatra[1*], A. A. Sha[2], I. Selvaraj[2], K. Nithin[2], J. Tista[2], P. S. Swain[3], S. Aravindh[1], M. Das[1], T. Panda[1] and S. Mishra[4]

[1]Department of Veterinary Physiology, College of Veterinary Science and Animal Husbandry, Odisha University of Agriculture and Technology, Bhubaneswar - 751 003, Odisha, India; [2]Wildlife SOS, Bannerghatta Bear Rescue Center, Bangalore - 560 083, Karnataka; [3]Dairy Cattle Nutrition Division, ICAR- National Dairy Research Institute, Karnal - 132 001, Haryana, India; [4]Department of Veterinary Biochemistry, College of Veterinary Science and Animal Husbandry, Odisha University of Agriculture and Technology, Bhubaneswar - 751 003, Odisha, India

Abstract

The study reports the differences in the electrocardiographic responses of young and adult Indian sloth bear *(Melursus ursinus)* to ketamine-xylazine anesthetic combination. Moreover, no baseline electrocardiographic data for Indian sloth bears is available in the literature. A twelve-lead standard ECG recorder was used and its electrodes of the electrocardiograph were connected over the olecranon and the patella. The configuration of the R wave was upright in most of the leads in both young and adults while inverted R wave was obtained in both age groups in lead aVR. The PR interval of young sloth bears was recorded as non-significantly ($p>0.05$) lower than that of adults. The QT interval was recorded significantly ($p<0.05$) higher in adults than in young sloth bears in all the bipolar and unipolar leads. RR interval in young sloth bears recorded significantly lower values in lead I and non-significantly lower values in the rest of the leads. Lead I and lead II of young sloth bears recorded significantly higher heart rates than adults. The QRS electrical axis ranged from 57 to 131 degrees in young and 66 to 77 degrees in adults. No cardiac distress or arrhythmia was evident from the electrocardiograms and use of ketamine-xylazine anesthetic combination for immobilization of sloth bears during ECG recording can be recommended. The results of the study can be used for ECG interpretation in Indian sloth bears.

Keywords: Age, Electrocardiogram, Indian sloth bear, Ketamine-xylazine anesthesia, *Melursus ursinus*

Highlights

- The study presented age-specific electrocardiographic parameter values for bipolar and augmented unipolar leads in Indian sloth bears.
- The study described the configuration of P wave and QRS complex across various leads.
- The findings of this study may serve as a reference for diagnosing ECG abnormalities in Indian sloth bears.

INTRODUCTION

The sloth bear is the most widespread bear species in India (Garshelis et al., 2011). It is listed in Schedule I of the Indian Wildlife Protection Act, 1972. The Indian sloth bear *(Melursus ursinus)* can easily be recognized by its shaggy black coat, long muzzle, protruding lip, and a white V-shaped patch on the chest (Surisetti et al., 2023). The International Union for Conservation of Nature (IUCN) estimated that less than 20,000 sloth bears inhabit the Indian subcontinent and Sri Lanka. Electrocardiography is a non-invasive and easily applied technique used in the determination of cardiac hypertrophy and dilatation, classification of cardiac arrhythmias, and diagnosis of conduction abnormalities (Mohapatra et al., 2015). There are also reports on the variable influence of two different anesthetic combinations on cardiac function in mice (Hart et al., 2001). Chemical immobilization is a necessary tool for research and management concerning wild animals. Since it is not possible to record ECG in active bears, breed-specific electrocardiographic values under a specific anesthetic combination will significantly contribute to the enrichment of scientific literature for the interpretation of electrocardiograms in sloth bears. This study aims to highlight the differences in the electrocardiographic response of young and adult Indian sloth bears to ketamine-xylazine anesthetic combination and establish a standard baseline data of their electrocardiographic values for Indian sloth bears

*Corresponding Author, E-mail: swagatmohapatra@ouat.ac.in

which will prove beneficial not only for research and monitoring purposes but also clinical treatment of these animals aiding in their conservation.

MATERIALS AND METHODS

Ethical approval: Electrocardiography is a non-invasive technique and the electrocardiograms were recorded during routine clinical examination of Indian sloth bears maintained in a semi-captive state at Wildlife SOS, Bannerghatta Bear Rescue Center, Bangalore, India. The animals were anaesthetized during routine examination and clinically monitored with electrocardiographic tracings at the Wildlife SOS center. The data generated was assessed and compiled for the present study.

Procedure: Adult Sloth bears aged between 12 to 20 years (n=6) and young bears aged between 2 to 3 years (n= 6) were considered for the study. Before chemical immobilization, the bears were fasted overnight although the animals had access to water. The bears were immobilized using a ketamine-xylazine combination and blowpipes were used for darting the animal. The immobilizing drugs were administered as per the dose (Hartley et al., 2025) i.e ketamine hydrochloride (5 mg/kg body weight; Ketamil, Troy Laboratories Pty Ltd., Smithfield, NSW, Australia) and xylazine hydrochloride (Xylazil, 2 mg/kg body weight; Troy Laboratories Pty Ltd.). A twelve-lead standard ECG recorder Technocare Medisystems model DP2020 digital single channel ECG recorder was used to record ECG in the bears**.** The electrocardiograph was set with a paper speed of 50 mm/sec and sensitivity of 1 (20 mm = 1 mV). The sloth bears were positioned in right lateral recumbency on an insulated table and the clips of the electrodes fitted to alligator clips were attached over the olecranon and the patella (Fig. 1).

Fig. 1. Electrocardiographic recording in Indian sloth bear

To minimize the variables associated with anesthetic depth, the ECG evaluation was conducted once a surgical anesthetic plane was achieved based on the lack of pedal reflexes. Statistical analysis was conducted using Microsoft Excel 2007, with significance determined at $p<0.05$ using Student's paired t-test.

RESULTS

The mean±SE values of different electrocardiographic parameters in bipolar limb leads and augmented unipolar limb leads are mentioned in Table 1 and Table 2. The sloth bears are designated as 'SB'. The configuration of 'P' waves and 'R' waves are represented in Tables 3 and 4 respectively.

Table 3. Configuration of 'P waves' in different leads

	Inverted	Upright	Total
Lead I			
Young	1	5	6
Adult	0	6	6
Lead II			
Young	0	6	6
Adult	0	6	6
Lead III			
Young	0	6	6
Adult	0	6	6
Lead aVR			
Young	6	0	6
Adult	6	0	6
Lead aVL			
Young	5	1	6
Adult	0	6	6
Lead aVF			
Young	0	6	6
Adult	0	6	6

Bipolar limb leads

Lead I: The electrocardiographic parameters in lead I that differed significantly between young and adults were T duration, QT interval, RR interval, ST segment, and heart rate. The mean electrical axis of the depolarization vector ranged from 57 to 131 degrees in young and 66 to 77 degrees in adults.

Lead II: The parameters that significantly varied between young and adults include R wave duration, QT interval, and heart rate.

Lead III: The parameters that were found to be significantly different in lead III electrocardiogram of adult and young SB include QT interval and heart rate.

Table 1. Electrocardiographic values of young and adult Indian sloth bears (Mean±S.E.) in bipolar limb leads

Group	P amp	P dur	Q amp	R amp	R dur	S amp	T amp	T dur	PR int	QT int	RR int	PR seg	ST seg	Heart Rate
Lead I														
Young	0.075±	0.056±	0.00±	0.166±	0.050±	0.025±	0.175±	0.083±	0.173±	0.200±	1.036±	0.116±	0.256±	58.01±
	0.012[a]	0.003[a]	0.00[a]	0.018[a]	0.004[a]	0.012[a]	0.012[a]	0.003[a]	0.004[a]	0.011[a]	0.024[a]	0.003[a]	0.003[a]	1.396[a]
Adult	0.066±	0.050±	0.041±	0.266±	0.058±	0.00±	0.158±	0.075±	0.176±	0.283±	1.520±	0.126±	0.16±	40.315±
	0.011[a]	0.005[a]	0.009[a]	0.059[a]	0.001[a]	0.00[a]	0.021[a]	0.006[b]	0.013[a]	0.017[b]	0.110[b]	0.011[a]	0.012[b]	2.817[b]
Lead II														
Young	0.108±	0.046±	0.042±	0.658±	0.026±	0.391±	0.458±	0.153±	0.140±	0.126±	1.133±	0.093±	0.240±	55.566±
	0.026[a]	0.010[a]	0.027[a]	0.135[a]	0.004[a]	0.142[a]	0.087[a]	0.031[a]	0.028[a]	0.013[a]	0.143[a]	0.019[a]	0.028[a]	5.017[a]
Adult	0.116±	0.063±	0.025±	0.783±	0.045±	0.108±	0.341±	0.120±	0.180±	0.303±	1.63±	0.116±	0.186±	37.803±
	0.011[a]	0.006[a]	0.014[a]	0.079[a]	0.003[b]	0.032[a]	0.038[a]	0.018[a]	0.011[a]	0.022[b]	0.144[a]	0.008[a]	0.034[a]	2.713[b]
Lead III														
Young	0.108±	0.043±	0.00±	0.583±	0.026±	0.383±	0.366±	0.116±	0.133±	0.143±	1.053±	0.083±	0.236±	64.281±
	0.021[a]	0.011[a]	0.00[a]	0.086[a]	0.004[a]	0.128[a]	0.064[a]	0.018[a]	0.023[a]	0.016[a]	0.177[a]	0.018[a]	0.035[a]	10.882[a]
Adult	0.116±	0.063±	0.025±	0.783±	0.045±	0.108±	0.341±	0.120±	0.180±	0.303±	1.63±	0.116±	0.186±	37.803±
	0.011[a]	0.006[a]	0.014[a]	0.079[a]	0.003[b]	0.032[a]	0.038[a]	0.018[a]	0.011[a]	0.022[b]	0.144[a]	0.008[a]	0.034[a]	2.713[b]

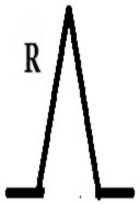
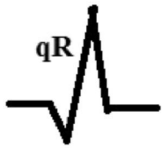
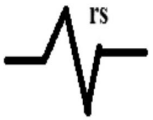
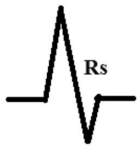
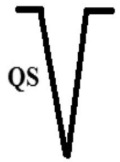
Means having different superscripts in a column differs significantly ($p<0.05$).

Table 2. Electrocardiographic values of young and adult Indian sloth bears (Mean±S.E.) in augmented unipolar limb leads

Group	P amp	P dur	Q amp	R amp	R dur	S amp	T amp	T dur	PR int	QT int	RR int	PR seg	ST seg	Heart Rate
Lead aVR														
Young	0.075±	0.043±	0±0	0.308±	0.030±	0.175±	0.250±	0.12±	0.143±	0.136±	1.073±	0.100±	0.236±	60.06±
	0.018[a]	0.008[a]		0.080[a]	0.004[a]	0.075[a]	0.006[a]	0.024[a]	0.022[a]	0.020[a]	0.150[a]	0.013[a]	0.033[a]	7.409[a]
Adult	0.200±	0.060±	0±0	0.433±	0.045±	0.033±	0.625±	0.093±	0.180±	0.290±	1.406±	0.120±	0.170±	43.266±
	0.120[a]	0.005[a]		0.036[a]	0.003[b]	0.018[a]	0.263[a]	0.007[a]	0.011[a]	0.012[b]	0.072[a]	0.012[a]	0.032[a]	2.408[a]
Lead aVL														
Young	0.075±	0.043±	0.00±	0.241±	0.033±	0.200±	0.175±	0.090±	0.133±	0.170±	1.113±	0.09±	0.243±	54.05±
	0.018[a]	0.008[a]	0.00[a]	0.045[a]	0.004[a]	0.072[a]	0.041[a]	0.020[a]	0.018[a]	0.017[a]	0.030[a]	0.010[a]	0.035[a]	1.418[a]
Adult	0.037±	0.026±	0.05±	0.233±	0.036±	0.079±	0.075±	0.046±	0.150±	0.273±	1.363±	0.118±	0.213±	45.295±
	0.006[a]	0.004[a]	0.034[a]	0.043[a]	0.006[a]	0.030[a]	0.012[a]	0.008[a]	0.016[a]	0.014[b]	0.111[a]	0.016[a]	0.023[a]	3.820[a]
Lead aVF														
Young	0.091±	0.043±	0.012±	0.641±	0.030±	0.366±	0.425±	0.143±	0.140±	0.140±	1.033±	0.096±	0.233±	71.036±
	0.016[a]	0.010[a]	0.009[a]	0.108[a]	0.004[a]	0.116[a]	0.065[a]	0.022[a]	0.022[a]	0.021[a]	0.218[a]	0.013[a]	0.032[a]	15.828[a]
Adult	0.075±	0.046±	0.016±	0.733±	0.051±	0.158±	0.266±	0.090±	0.170±	0.270±	1.466±	0.121±	0.203±	42.508±
	0.012[a]	0.004[a]	0.011[a]	0.091[a]	0.010[a]	0.029[a]	0.050[a]	0.007[a]	0.012[a]	0.018[b]	0.149[a]	0.015[a]	0.040[a]	3.828[a]

Means having different superscripts in a column differs significantly ($p<0.05$).

Table 4. Configuration of QRS complex in young (n = 06) and adult (n = 06) sloth bears

								Toatal
	r	R	qr	qR	rs	Rs	QS	
Lead I								
Young	5						1	6
Adult	4	2						6
Lead II								
Young		1			2	3		6
Adult		2				4		6
Lead III								
Young		1				5		6
Adult		2				4		6
Lead aVR								
Young				1			5	6
Adult			1	2			3	6
Lead aVL								
Young			1				5	6
Adult			4				2	6
Lead aVF								
Young		1			2	3		6
Adult	2						4	6

Augmented unipolar limb leads

Lead aVR: The duration of the R wave and QT interval were among the electrocardiographic parameters that revealed significant variation among age groups.

Lead aVL: The QT interval was the only parameter that varied significantly within groups in lead aVL.

Lead aVF: The QT interval is the only parameter that altered significantly within groups in lead aVF.

DISCUSSION

The amplitude of the P wave obtained in lead I, III, aVL, and aVF was insignificantly higher in young SB in comparison to adults while higher P wave amplitude was found in adults with respect to young in lead II and lead aVR although the difference was statistically insignificant. The duration of the P wave in all the leads also varied insignificantly in young and adults and was mostly wider in adults suggesting dilatation of atria with advancing age (Pradhan et al., 2017). The P wave in young and adult SB was upright in most of the leads while inverted P wave was obtained in lead aVR in both young and adult SB. The configuration of the P wave showcased a marked alteration in lead aVL i.e in the case of young, an inverted P wave was observed in the majority of the cases while in adults, an upright P wave was reported in the majority of the cases. All leads have different axes. Variation in the configuration of the P wave in both age groups with respect to different leads might be due to the difference in the mean P vector with respect to axis of the leads. Although there were slight variations, nevertheless the atrial depolarization events were almost similar in both young and adult SB. The Q wave was absent in most of the leads in young SB whereas the Q wave was prominent in adults in most of the leads. Q wave represents normal left to right depolarization of the inter ventricular septum. The variations in the amplitude of the Q wave in young and adult SB are in agreement with a similar line of research carried out in dogs of different age groups (Mohapatra et al., 2012).

The amplitude of the R wave was insignificantly higher in adults compared to young with respect to most of the leads. The R wave duration differed significantly in lead II and aVR. Relatively higher R wave duration may be an indication of more time required for depolarization in adult SB. The configuration of the R wave was upright in most of the leads in both young and adult while inverted R wave was obtained in both age groups in lead aVR. Contrastingly, both 'qr' and 'QS' configuration was obtained in lead aVL in different SB. The mean QRS electrical axis ranged from 57 to 131 degrees in younger and 66 to 77 degrees in adults. The change in the electrical axis as age advances is apparently the reason behind different configurations of R waves in different age groups. Tall R waves in adult bears indicate hypertrophy of the ventricles with increasing age. Ventricular hypertrophy facilitates pumping more blood from the heart so as to maintain the cardiac output with increasing age. There was a low amplitude of R wave in lead I in both adult and young SB. R wave showing low amplitude may be due to the high degree of synchronized ventricular depolarization (Mohan et al., 2005).

There was a wide variation among T wave amplitude in young and adult SB. The variations in T wave in young SB might be due to differences in the anatomical distribution of Purkinje fibers resulting in variable repolarization time of the ventricles (Mohapatra et al., 2017).

The PR interval of young SB was recorded as insignificantly lower than that of adult SB. This lower value of PR interval might be due to faster atrioventricular conduction time in younger SB. Nevertheless, our values of PR interval were higher than the values of PR interval reported by Gandolf et al. (2010) in free-ranging brown bears (*Ursus arctos*).

The QT interval is the time from the start of the Q wave to the end of the T wave which represents electrical depolarization and repolarization of the ventricles. The QT interval was recorded as significantly higher in adult SB as compared to young SB in all the bipolar leads and unipolar leads. A larger QT interval indicates the need for a longer time for repolarization (Diniz et al., 2017). Lower heart rate, autonomic nervous activity and higher age of adult SB may be the determinants of prolonged QT interval (Locati et al., 2017). Our finding is in concordance with a similar line of research which concluded higher QT interval with advancing age in large white Yorkshire piglets (Mohapatra et al., 2016).

RR interval in adult SB was recorded to be significantly lower in lead I and non-significantly lower with respect to young SB in the rest of the leads. A shorter RR interval reveals less time interval between successive heartbeats in young SB. This is in agreement with the recordings which showed that the mean of normal R-R intervals slightly increased with age, which may be due to extracardiac regulatory factors (Mongue-Din et al., 2009).

Lead I and lead II of young SB recorded significantly

higher heart rates than adult SB. Higher heart rate in young SB could be attributed to their less developed tonic vagal inhibition and relatively smaller size (Reece & Rowe, 2017). However, our study reported lower heart rates than those reported by studies on brown bears (Gandolf et al., 2010). The bradycardic effects of ketamine-xylazine anesthetic combination had been reported in mice (Hart et al., 2001). The anesthetic combination used by us might be the reason for getting lower heart rates. Sinus arrhythmia was evident in all bears due to variations in vagal tone during respiration which is considered to be a normal finding in the electrocardiograms.

The study highlighted the difference in electrocardiographic response of young and adult Indian SB to ketamine-xylazine anesthetic combination. Baseline electrocardiographic reference values of Indian SB in two different age groups with respect to different leads were also established. The study highlighted the morphological pattern of P waves and R waves in different leads of ECG and also reported the variation in configuration of different ECG waves with respect to age and also within the same age group. The study concludes that age-specific electrocardiographic reference values should be considered while interpreting ECG in the Indian sloth bear. The study also recommends the use of ketamine-xylazine anesthetic combination while performing ECG as there is no cardiac distress or arrhythmia associated with it. The authors infer that the study will be quite helpful in veterinary clinical practice for diagnosis of cardiac problems in Indian sloth bear or while considering interpretations for other Ursids.

Conflict of interests: The authors declare that they have no competing interests.

Data availability statement: Data set generated during research will be available from the corresponding author on reasonable request.

Author's contribution: SM, AAS, PSS: Conception and design; SM, AAS, IS, KN, JT, SA: Acquisition of data; MD, TP, SA: Performed statistical analysis of data; PSS, ASA, SwM: Performed interpretation of results

Ethical statement: Materials for the study were obtained by compiling the already available data from the routine clinical evaluation of Indian sloth bears at Wildlife SOS, Bannerghatta Bear Rescue Center, Bangalore.

Use of artificial intelligence tools: No artificial intelligence tools were used for preparation of the work.

ACKNOWLEDGEMENT

We greatly appreciate the support of Executive Director, Bannerghatta Biological Park, Karnataka, India, Mr Kartick. S and Mrs G. Seshamani Co-founders of the Wildlife S.O.S. who made these studies possible. We thank the animal care staff at Wildlife S.O.S., India; for all their assistance during the period of this study.

REFERENCES

Diniz, A. N., Pessoa, G. T., Moura, L. D. S., Sanches, M. P., Rodrigues, R. P., Sousa, F. D. C., Ambrocia, C. E., & Alves, F. R. (2017). Computerized electrocardiogram in agoutis (*Dasyprocta prymnolopha* Wagler, 1831) anesthetized with ketamine and midazolam. *Pesquisa Veterinária Brasileira*, *37*, 150-155. https://doi.org/10.1590/S0100-736X2017000200009

Gandolf, A. R., Fahlman, Å., Arnemo, J. M., Dooley, J. L., & Hamlin, R. (2010). Baseline normal values and phylogenetic class of the electrocardiogram of anesthetized free-ranging brown bears (*Ursus arctos*). *Journal of Wildlife Diseases*, *46*(3), 724-730. https://doi.org/10.7589/0090-3558-46.3.724

Garshelis, D. L., Joshi, A. R., Smith, J. L., & Rice, C. G. (1999). Sloth bear conservation action plan. In: C. Servheen, S. Herrero, & B. Peyton, (Eds), *Bears: status survey and conservation action plan.* International Union for the Conservation of Nature and Natural Resources, Gland, Switzerland, 225-240.

Hart, C. Y., Burnett Jr, J. C., & Redfield, M. M. (2001). Effects of avertin versus xylazine-ketamine anesthesia on cardiac function in normal mice. *American Journal of Physiology-Heart and Circulatory Physiology*. https://doi.org/10.1152/ajpheart.2001.281.5.H1938

Hartley, C., Busse, C., Riera, M. M., Bacon, H. J., Arun, A. S., Selvaraj, I., Satyanarayan, K., Seshamani, G., & Knight, A. (2025). Ocular findings in sloth bears (*Melursus ursinus*) rescued from the dancing bear trade in India. *Journal of Zoo and Wildlife Medicine*, *56*(1), 104-112. https://doi.org/10.1638/2023-0117

Locati, E. T., Bagliani, G., & Padeletti, L. (2017). Normal ventricular repolarization and QT interval: ionic background, modifiers, and measurements. *Cardiac Electrophysiology Clinics*, *9*(3), 487-513. https://doi.org/10.1016/j.ccep.2017.05.007

Mohan, N. H., Niyogi, D., & Singh, H. N. (2005). Analysis of normal electrocardiograms of Jamunapari goats. *Journal of Veterinary Science*, *6*(4), 295-298. https://doi.org/10.4142/jvs.2005.6.4.295

Mohapatra, S., Dwivedy, S., Mohapatra, S. S., Mahapatra, A. P. K., & Kundu, A. K. (2015). Comparison of electrocardiogram between young and adult male Ganjam sheep of Odisha. *Indian Veterinary Journal*, *92*(6), 66-68.

Mohapatra, S., Kundu, A. K., & Mahapatra, A. P. K. (2012). ECG study in apparently healthy dogs. *Indian Journal of Field Veterinarians*, *7*(4), 47-48.

Mohapatra, S., Swain, L., Gitika, A., Priyadarsini, L., Jyotiranjan, T., Mahapatra, A. P. K., & Kundu, A. K. (2017). A comparative evaluation of lead II electrocardiograms obtained from Labrador Retriever dogs in different body positions. *Indian Veterinary Journal*, *94*(02), 17-19.

Mohapatra, S., Jyotiranjan, T., Dey, H. S., Mahapatra, A. P. K., & Kundu, A. K. (2016). Influence of age on the electrocardiographic outline of large white Yorkshire piglets. *Indian Veterinary Journal*, *93*(06), 42-45.

Mongue-Din, H., Salmon, A., Fiszman, M. Y., & Fromes, Y. (2009). Periodic variation in RR intervals and cardiovascular autonomic regulation in young adult Syrian hamsters. *American Journal of Physiology-Regulatory, Integrative and Comparative Physiology*, *296*(3), R610-R617. https://doi.org/10.1152/ajpregu.90376.2008

Pradhan, R. R., Mahapatra, A. P. K., Mohapatra, S., Jyotiranjan, T., & Kundu, A. K. (2017). Electrocardiographic reference values and configuration of electrocardiogram waves recorded in Black Bengal goats of different age groups. *Veterinary World*, *10*(9), 1020-1025. https://doi.org/10.14202/vetworld.2017. 1020-1025

Reece, W. O., & Rowe, E. W. (2017). *Functional Anatomy and Physiology of Domestic Animals*. Wiley Blackwell, New Jersey.

Surisetti, R., Pattasi, J., & Mallarapu, P. (2023). Sloth bear (*Melursus ursinus*) maternity denning behavior observations at Indira Gandhi Zoological Park, Visakhapatnam. *Asian Journal of Research Zoology*, *6*(2), 19-25. https://doi.org/10.9734/ajriz/2023/v6i2108

Received - 13.04.2025, *Accepted - 10.08.2025*, *Published - 08.09.2025 (Online)*
Section Editor: Dr. Joydip Mukherjee, Editorial Board Member