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ACOUSTICS AND ACTIVITY PATTERN OF LEAF NOSED BATS OF MUNDANTHURAI PLATEAU OF SOUTHERN WESTERN GHATS, INDIA

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ABSTRACT: Bat only flying mammalian species, among the diverse species existing in the forests of Kalakad Mundanthurai Tiger Reserve (KMTR) of the southern Western Ghats, India. Bats are important component of the forest ecosystem. Nocturnal foraging behaviour, echolocation, dentition and flight manoeuvrability adaptations enhance their ability to capture nocturnal prey items. Acoustic monitoring and survey helps in determining population density of bats. The present study show that acoustic survey carried out in *Hipposideros* species has rich population density and wide distribution in the forest ecosystem of KMTR.

KEYWORDS: *Hipposideros*, Nocturnal, Echolocation, Acoustic detection, Echocalls.

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1.INTRODUCTION

Bats are unique fascinating and are the only true flying mammals under the mammalian order Chiroptera. Bats are an important component of the ecosystem. Dietary variations classify them into two sub-orders namely, Megachiroptera (fruit bats) and Microchiroptera (insect-eating bats). There are many indications to say that they have a significant ecological role in the environment [11], [31], [32], [34]. Megabats as pollinators and seed dispersers, and insect-eating Microbats as insect control agents of the ecosystem. Microbats are nocturnal in habit and utilize ultrasonic echolocation calls to navigate and forage insects during the night.

2. MATERIALS AND METHODS

Insectivorous bats play a significant role in pest management in all forested ecosystems [9], [2], [6]. They are the most sociable and prosperous group of beneficial animals to the ecosystem. Their species richness and activity patterns indicate the habitat status. In recent years bat monitoring studies have been improved by using advanced acoustic technology (using ultrasonic bat detectors) which allows the investigators to hear and visualize ultrasonic echolocation calls of bats [16], [1], [15]. Among the microbats, leaf-nosed bats (members of the family Hipposideridae) are the widespread insectivorous bat species inhabiting the forest ecosystem of the Southern Western Ghats. Extensive studies made by the team led by [29] on the distribution of bat species in Agasthiyarmalai Biosphere Reserve since 2000 [29], [30], [33], [35] has recorded three *Hipposideros* species. They are *Hipposideros fulvus* (Fulvous leaf-nosed bat), *Hipposideros pomona* (Andersen's leaf-nosed bat), and *Hipposideros speoris* (Schneider's leaf-nosed bat). The family Hipposideridae members are characterized as 'Leaf-nosed bats' and closely allied to the family Rhinolophidae by possessing peculiar similar nose leaf. Bats sonar system is so efficient that it can snatch flying insects from the air and navigate in complete darkness [22], [24]. Analyzing bat's biosonar echolocation call structure through bat detectors tells about their habitat utilization [28], [24]. The present study has used two ultrasonic detectors (Anabat SD1, Wildlife Acoustics Echo Meter EM3) for the identification and survey of *Hipposideros sp.* bats. The study period of two years, covered the prevailing four seasons. Acoustic Monitoring: Reference calls were recorded through bat detectors from the captured *Hipposideros* bat species kept in various situations (inside bat bag, held in hand, flying indoors, and hand released). The recorded *Hipposideros sp.* calls help to measure typical call characteristics such as call shape, frequency, and other temporal features. To study the activity patterns the bat detectors were set up in the selected niches of bat pathways at various research stations of Mundanthurai plateau from dusk 18.00 hrs to dawn 6.00hrs when the bats were active in foraging. Echo call monitoring at multiple sites helps to compare bat species activity throughout the night in different habitats and is also used to identify species richness. Bat calls were analyzed through acoustics software Bat sound 4.1, Analook W, and Kaleidoscope Installer – 0.4 – 14.exe. For each recording, the numbers of bat passes were filed and considered as a relative index of the species. The activity of each bat species was determined from the total number of bat passes recorded per site per day. Statistical analysis was helped to pool and compare recorded data of the study sites. Data are expressed as mean ±SD. The student's t-test was used to analyze differences in mean. ANOVA was performed to assess overall differences between the bat activities in the study sites. A value of $P<0.05$ was considered statistically significant. To find out the dependent phenomena of the bat activity in habitat analyze were made between the bat activities in habitat variables to predict the bat activity trend analysis.

3. RESULTS AND DISCUSSION

A single emission of sound is referred to as a call and a series of calls in a call sequence [5]. Bats use separate pulses of sound containing very pure tones that have time-frequency and amplitude components. Bat echolocation calls comprise different types of frequency structures. CF tone is a narrow band signal. The sound stays constant frequency throughout its duration. CF signals were recorded from rhinolophid and hipposiderid bats. These calls are typically longer (10 to 100ms), with most of their energy in a narrow frequency band. CF components serve to assist in the detection of targets. Bats produce a complicated sequence of calls, combining CF and FM components echo call. The echolocation call structures of Hipposiderids have constant frequency with frequency-Modulated component signals. *H. fulvus* and *H. speoris* bats produce long Constant Frequency and Frequency Modulations (CF-FM) echo calls and *H. pomona* short constant frequency components proceeding to frequency modulation sweep. The CF-FM bats tolerate overlap of outgoing sounds and returning echoes because the sonar vocalizations and returning echoes stimulate separate frequency channels in the bat's auditory system [20] (Table 1, Plate 1).

Table 1: Measurements of Echocalls: Mean ± Standard Deviation; FMAXE; Maximum Frequency.

S.No	**Name of the bat species**	**Call structure**	**Call duration (ms)**	**FMAXE (kHz)**	**Interpulse interval**
1	*Hipposideros fulvus*	*CF/FM*	7.4±1.5	142±0.4	5.3±0.9
2	*Hipposideros speoris*	*CF/FM*	8.1±1.6	136±0.3	15.6±10.3
3	*Hipposideros pomona*	*CF/FM*	8.8±1.2	130±0.2	13.4±0.4

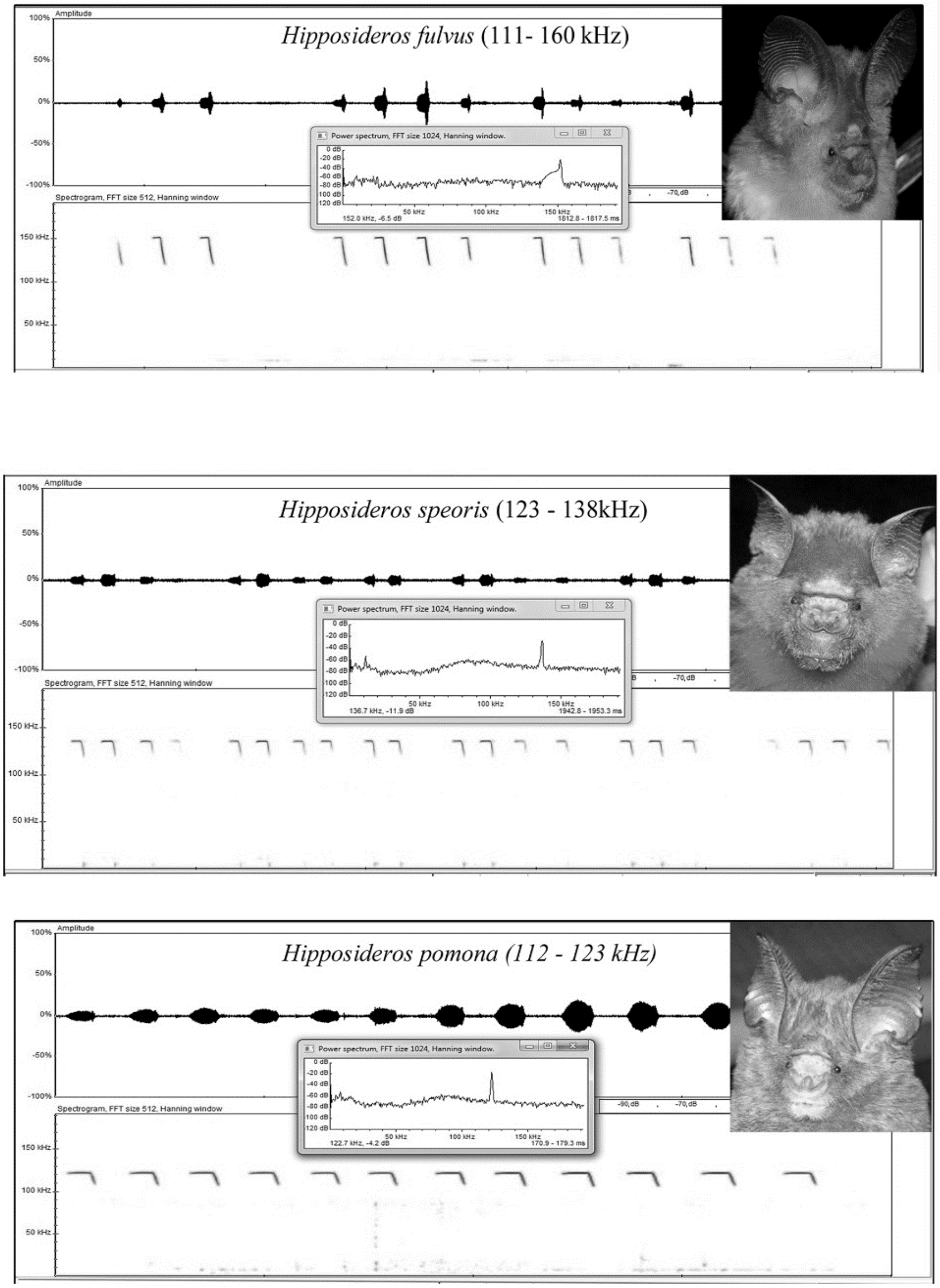

Plate 1: Echocalls of Hipposideros bats recorded and viewed through Bat sound software

Among the study animal, Rhinolophidae and Hipposdieridae bats produce constant frequency calls. The duration of calls of Rhinolophidae bats is relatively longer than the calls of Hipposideridae bats. Specifically, hipposiderid CF calls are short and shorter in duration (*H. speoris* 8.1±1.6ms, *H. fulvus* 7.4±1.5ms, *H. pomona* 8.8±1.2ms) the most difficult species in hipposiderid bats assemblage to identify acoustically are likely to be *H. pomona*, whose very high-frequency calls attenuate over short distances [12]. FMAXE of *H. pomona* varies from 121–140 kHz across its range [8], [26], [25], [7], [10], [37], [4], [14]. The present study recorded the FMAXE of *H. pomona* is 130±0.2 KHz, a distinctive feature that helps distinguish this species call from its morphologically similar congener especially the fellow occupants, *H. speoris* with FMAXE of 136±0.3kHz and *H. fulvus* with FMAXE of 142.6±0.4kHz. Short broadband calls apparently do not permit bats to operate in dense clutter. Hipposideros bats are incomplete in Doppler shift compensation. These bats are only able to partially compensate for Doppler shifts in echoes [13] because of their short CF calls. High duty cycle calls allow bats to take advantage of the information contained in Doppler-shifted echoes generated by the relative movements of bat and target, including acoustic glints generated by the wingbeats of fluttering insects. The Hipposideros bat activity in the research stations is described based on the number of bat pass recorded (Figure 1). Habitat heterogeneity affects activity richness [21], [19], [36]. The present research also confirms that the activity richness is high in the forested area (58%) than the human settlement area (35%) of the Mundanthurai plateau (Figure 2). This variation may be due to the presence of tribal hamlets, hydroelectric dam sites, electricity board quarters that causes more interferences. The variability also depends on the availability of food and roosting sites.

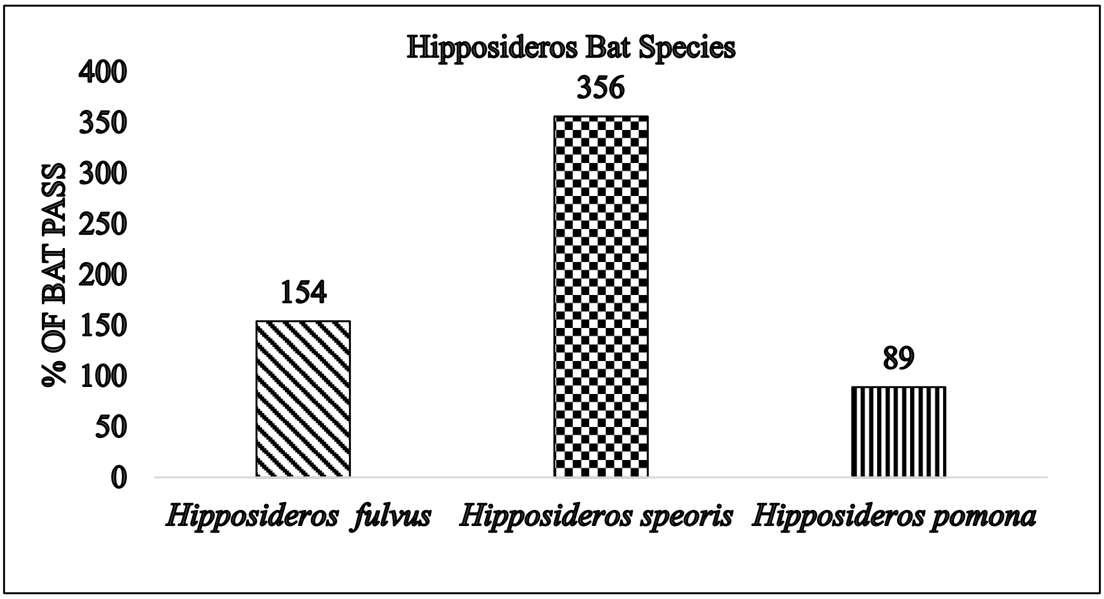

Figure 1: Hipposideros bat activity in the Research stations

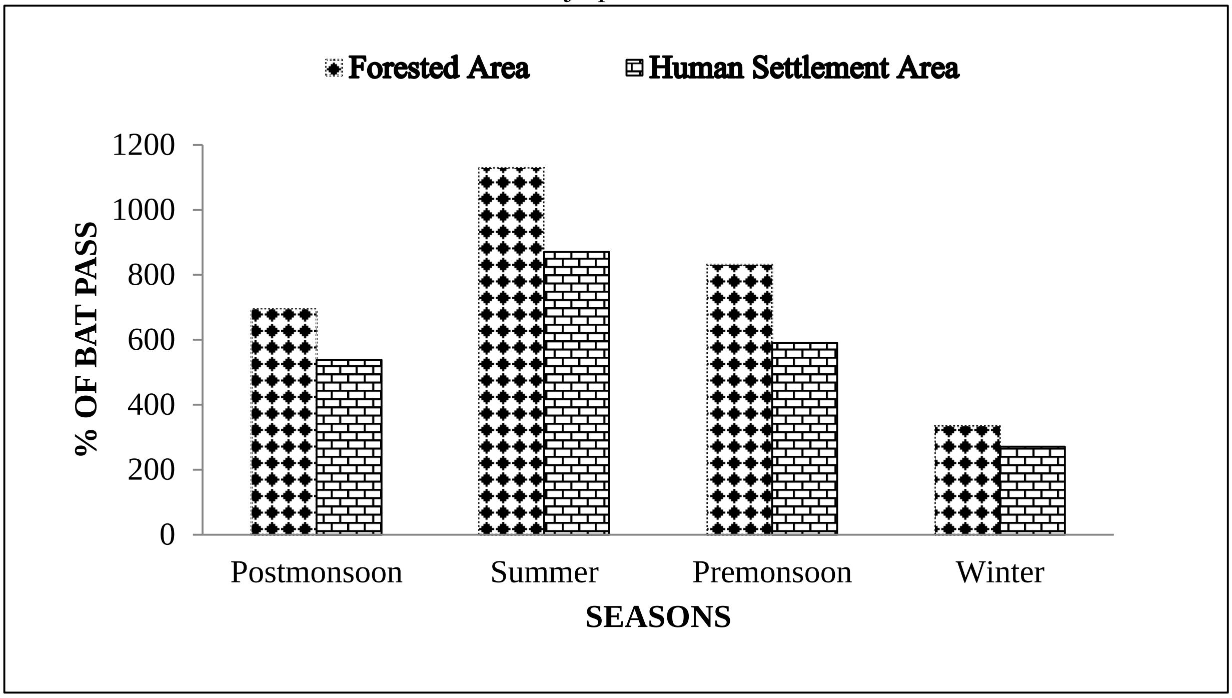

Figure 2: Hipposideros bat activity four seasons in the Research stations

Comparison of seasonal variation in the bat species study area is statistically defined by applying statistical tools likes Pearson's correlation and F test. Correlation coefficients measuring the comparison of seasonal activity between summer and Monsoon (r:9484), Summer and winter (r:9521), and monsoon and winter (r:9253) have confirmed that the relationship between the variables is strong. F test (testing significance of regression) results confirmed that the relationship between summer and monsoon has a positive correlation and that of summer and winter and monsoon and winter have a negative correlation. During summer and monsoon, the bat species activity is high, and during winter it's comparatively low. The bat activity in the research stations are described based on the number of bat pass recorded. the insectivorous bats appear to have adjusted their nightly activities to match those of their prey, thereby maximizing foraging success and energy gains. Of the hourly activity-based bat activity among the hipposiderid bat species two bimodal activity patterns *H. speoris*, *H. fulvus* and one of them *H. pomona* is trimodal activity pattern (Plate 2). Several environmental factors such as temperature, humidity, road infrastructure and traffic, ecological light pollution and the distribution and diversity of prey and moonlight have been reported to affect the flight activities of insects [18], [27] and can consequently be thought directly or indirectly influence bat activity as well.

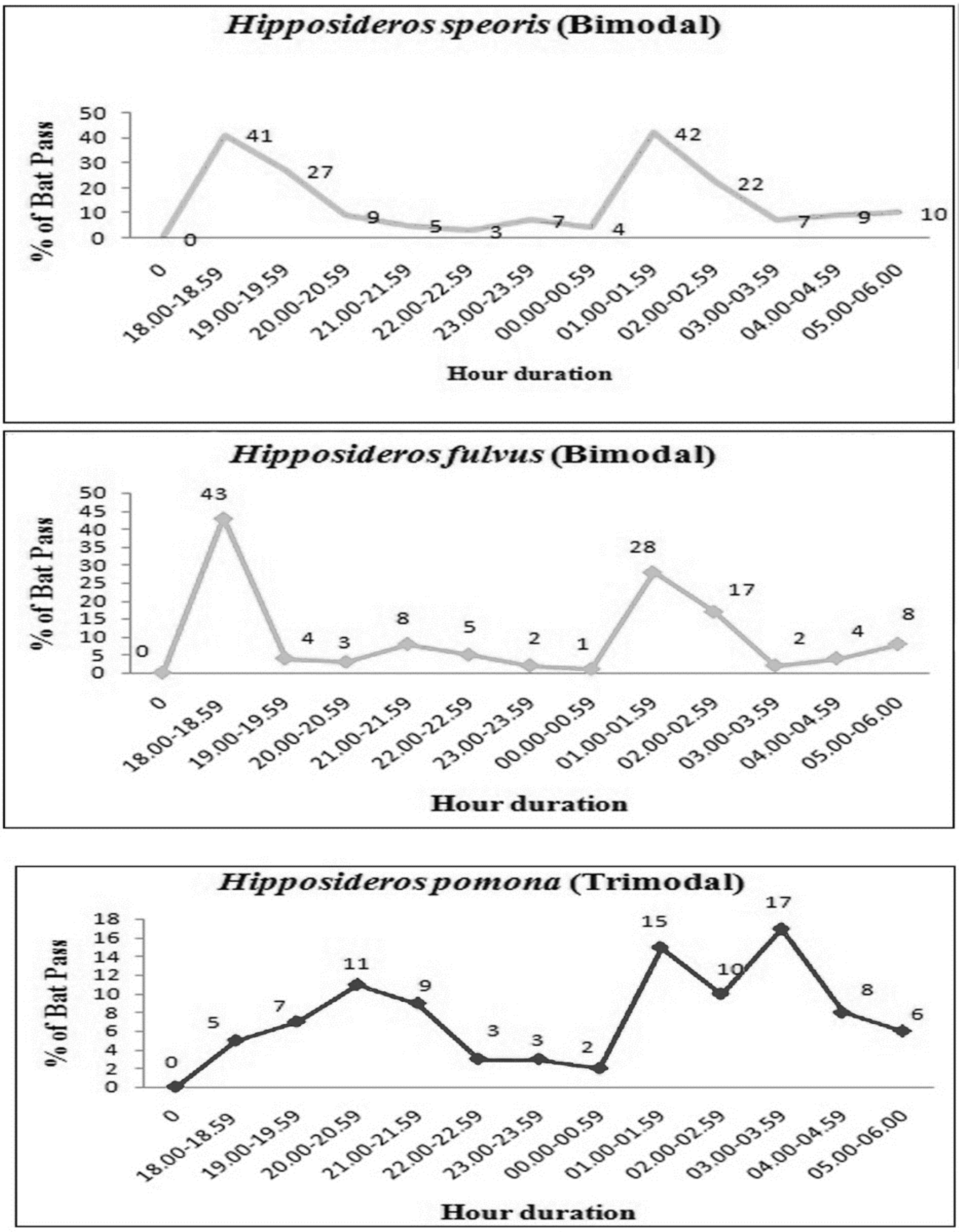

Plate 2 : Hourly activity patterns of Hipposideros bats between dawn and dusk

Studies by [30] on activity patterns and habitat preferences of insectivorous bats in a West African forest–savannah also supports that, bat activity was significantly and positively related to insect availability and ambient temperature. Peaks of activity coincide with overnight peaks in insect activity. Pattern analysis done by [17] proved that *R. hipposideros* exhibit multimodal phases of activity in relation to prey availability in certain habitats and seasons. [3] Exploratory work has indicated multimodal phases of activity related to the prey availability. Studies of [27] show that reduction of prey availability explains unimodal or bimodal behavior, as peaks of activity coincide with peaks in insect numbers at dusk and, to a lesser extent, dawn. However, some moth species (non-volant prey), which are active all night with a peak in their activity occurring around midnight [23] similarly swarming of insects are predominant at dusk and dawn hence resulting in trimodal or multimodal activity patterns in bats. The activity pattern is also affected by temperature, wind speed, rainfall, and insect availability [17]. The insectivorous bats thus appear to have adjusted their nightly activities to match those of their prey, thereby maximizing foraging success and energy gains.

4. CONCLUSION

Kalakad Mundanthurai Tiger Reserve is ecologically rich for distribution of forest bats, Microchiropteran bats are a tool to know more about their interaction and impact in the forest of Mundanthurai. The majority of bats found foraging in forest wetlands and they often move between different types of habitats, like day roosts and nocturnal foraging sites. Selection of foraging habitat largely depends on availability of diet and seasonal variation in insect availability. Monitoring forest habitation through bioindicators such as bat's diversity, species richness and activity patterns will be a good tool to indicate the habitat status in a long way provide robust data in support recovery, survival and biodiversity conservation. The present study focused on the impact of *Hipposideros sp.* in the ecosystem Mundanthurai Plateau of Kalakad Mundanthurai Tiger Reserve. Studies of [33] has proved that these bats play a key functional role in all the different types of forested ecosystems, acting as predators of insects, including harmful forest pests. Their nature of activity and frequent use of night roost and alternative day roosts is a significant aspect of *Hipposideros sp.* behaviour, should be considered carefully by conservation planners while designing management strategies to conserve these species.

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CONFLICT OF INTEREST

Authors have no any conflict of interest.

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