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Distribution and Status of the Lesser known Madras Hedgehog *Paraechinus nudiventris* in South Tamil Nadu, India

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Abstract

Hedgehogs recognized by their spines able to roll into a tight ball in self-defense with spines pointing outwards. Hedgehogs are nocturnal and hibernate depending on temperature, species and abundance of food. The South Indian Hedgehogs is least studied and are steadily declining in rural areas especially from large areas of agricultural land. The major distribution habitats are shrubs, small hillocks and thorny shrubs. The main threats for these spiny small mammals are hunting, habitat loss, habitat fragmentation, injuries, road kill, lack of invertebrate prey, local trade, difficulty in long term monitoring leads to least concern on theses small mammals. The declining status of Hedgehog population made this to enter into endangered species lists.

Keywords: Conservation, Habitat, Nocturnal, Shrubs, Small Mammal, Spiny

1. Introduction

Global climate changes, habitat alteration, pollution and rapid growing of human population are increasing the pressure on natural resources and ecosystems on earth[2]. Recent research gave evidence of negative climate change impact on almost 700 threatened mammals and bird species[3]. Therefore, it is high-time to restore habitat within an ecosystem for the conservation of globally threatened and indicator species[4,5]. In order to restore the habitat of threatened species in an ecosystem, a broad knowledge of their potential habitat data is a prerequisite[1]. Small mammals are likely to become extinct as larger species, although they receive little attention with respect to conservation and research[42]. The conservation status of many small mammal species remains poor with little data on taxonomic knowledge, distribution and population status[4].

Insectivore animals are usually small in size, long narrow snouts and five clawed digits on each limb. The body generally covered with a short hair, fur or hard spines. Eyes are small and the teeth are very primitive in structure[27]. Hedgehogs are small terrestrial, insectivorous mammals with a spiny integument placed under the family *Erinaceidae* and subfamily *Erinaceinae* where only 18 species in five genera are currently recognized till last year[17,32]. Hedgehogs have a very wide distribution ranges and they are native to Eurasia and Africa[12,13]. In 2018, the recent discovery of a new hedgehog *Mesechinus wangi* from Gaoligongshan National Nature Reserve, southwestern Yunnan, China (2100 to 2680 m)[2] increased the small mammal researcher's attention more. Classification of the species of hedgehogs within five genera was proposed on the basis of their morphological, Osteological and Odontological features[12,13]. In South Asia five species are represented such as, *Hemiechinus auritus*

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(Long-eared Hedgehog), *Hemiechinus collaris* (Collared or Indian long-eared hedgehog), *Paraechinus hypomelas* (Brandt's Hedgehog) with *Paraechinus micropus* (Indian Hedgehog) and *Paraechinus nudiventris* (Bare-bellied or Madras Hedgehog). Of these H. *Collaris*, *P. micropus* is common in South Asia and *P. nudiventris* are found in Southern India especially in Andhra Pradesh, Tamil Nadu and Kerala.

The Indian long-eared hedgehog (*Hemiechinus collaris*) which comes under least conservation status has a well-developed set of senses because of its large ears, eyes and whiskers near its snout[5]. Many of desert hedgehog species belonging to the genus *Paraechinus* occur in arid and semi-arid environments and only less information is available on their ecology and biology[3,26,43.] The Indian long-eared hedgehog is insectivorous, feeding on small insects. Because of their arid desert habitat, they often receive water from their food supply for survival[35]. It is a small nocturnal animal that is often found inhabiting burrows[15]. It is found in North West Frontier Province, Punjab and Sindh of Pakistan and Gujarat, Rajasthan and Uttar Pradesh of India. It tolerates extreme heat in the months of May and June and very cold weather in December and January[35].

Hedgehogs are easily recognizable insectivore mammals belonging to the order Erinaceomorpha and family Erinaceidae, which includes 16 species and five genera[17]. The two genera; *Hemiechinus* and *Paraechinus* have been reported in South Asia[12,18]. Indian hedgehogs are nocturnal elusive animals and are seen only in hedges[21]. *Paraechinus nudiventris* is one of the three hedgehog species distributed in India[39].

Paraechinus nudiventris (Madras Hedgehog) is an endemic insectivore species known from Tamil Nadu, Andhra Pradesh and Kerala states of Southern India[11,18,22]. *P. nudiventris* is the only hedgehog endemic to India, occurring mainly in few districts within Tamil Nadu, Andhra Pradesh, Kerala, Karnataka and Pondicherry[19]. Historically, *P. nudiventris* was common in plains of Southern India, abounded in Madras presidency (Avinashi, Perundurai, Madras and Beypore railways, between Salem and Coimbatore) Ramanathapurum district[42], Highways[19], lower rocky hills of Tirunelveli[41], Eastern slopes towards the base in Nilgiris.

As in earlier findings[22] it is nocturnal, sleeping in rolled up position throughout the day and feed termites and insects. The habitat includes semi-arid scrub forests, thorny areas, dry lands, cattle grounds, bushy deserts, grass lands, edges of cultivated areas and dried ponds. *P. nudiventris* are fossorial, nocturnal animals living in dry, hot climatic conditions such as dry deciduous scrubby areas dominated by Acacia and rocky habitats[11].

The previous distribution location includes Thiruchirapalli[42], first described the morphology and skull of Indian hedgehogs and further there is no extensive taxonomy and distribution survey. The distribution of *P. nudiventris* species is presumed to be restricted[37] and there currently only a few available publications as occasional encounters[22]. No conservation action is known to have been taken nor long term research conducted on hedgehogs in India[25].

The recent records were from Kalakad Mundanthurai Tiger Reserve[19] in Tamil Nadu. In Kerala it is reported from Ottapalayam, Palakkad and Periyar Tiger Reserve[40]. The distribution of *P. nudiventris* species is presumed to be restricted[37] and currently only a few available publications as occasional encounters[23]. The most significant work on the Indian hedgehog provides comprehensive accounts of distribution and status of the hedgehog. However[8,24] little fieldwork has been carried out on this animal with respect to the distribution and status of a natural population of hedgehogs. Similar to most hedgehogs its back is embedded on muscle sheath.This sheath forms bags like structure that the animal can hide inside for protection. It can also erect its spines to further protect from predators[24].

Except a few anecdotal notes and few records there is no detailed ecological study and conservation plans for this species[25]. Foxes, jackal and grey mongoose are found to be the predators. However, the species falls under the Least Concern by IUCN Red List[11].

In this study, we have investigated distribution of *P. nudiventris* in Tirunelveli and Tuticurin districts of state Tamil Nadu by field work and community interviews in 2016 to 2017. In addition, we have informed the species biology and ecology is a study area is considered to offer ideal habitats for hedgehogs.

2. Study Area

Tamil Nadu is the largest state of India and is located in the southernmost part of Indian peninsula, occupying an area of 130,060 km^2. It is surrounded by the Eastern Ghats on the North side, Nilgiri, Anamalai Hills and Kerala on West side, Bay of Bengal in the East side, Gulf of Mannar

and Palk Strait on the Southeast and Indian Ocean on the South. The western, southern and the north western parts of Tamil Nadu are hilly and covered by dense vegetation.

Tirunelveli described as microcosm of the state is the penultimate South most district of Tamil Nadu. It is covered with diverse geographical and physical features such as lofty mountains and low plains, dry red sand dunes, rivers and cascades, sea coast and thick inland forests. Tirunelveli district lies between 08°8' and 09°23' N latitude and 77°09' and 77°54' E longitude.

Tuticurin district is surrounded by Bay of Bengal and districts of Tirunelveli, Kanyakumari and Ramanathapurum. With diverse geographical and physical features such as lofty mountains and low plains, dry Teri landscapes, seacoast and thorny scrub jungles, it lies in 08° 45'of N latitude and 78°13' E longitude. Totally eight unique sites were chosen in Tirunelveli and Tuticurin Districts of Tamil Nadu (Figure 1).

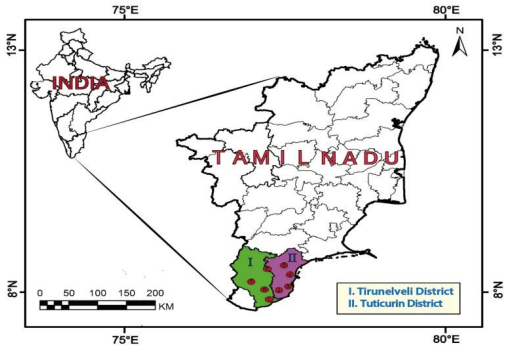

Figure 1. Location of Tirunelveli and Tuticurin districts surveyed for Madras Hedgehog *Paraechinus nudiventris* in south Tamil Nadu, India.

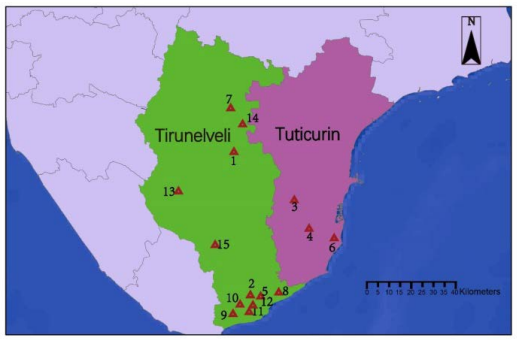

Figure 2. Present distribution locations of Madras Hedgehog *Paraechinus nudiventris* in Tirunelveli and Tuticurin districts of Tamil Nadu, India. Numbers denote areas mentioned in the Table 1. All the locations retrived from field surveys carried out in 2016 - 2017 in dry lands of the districts.

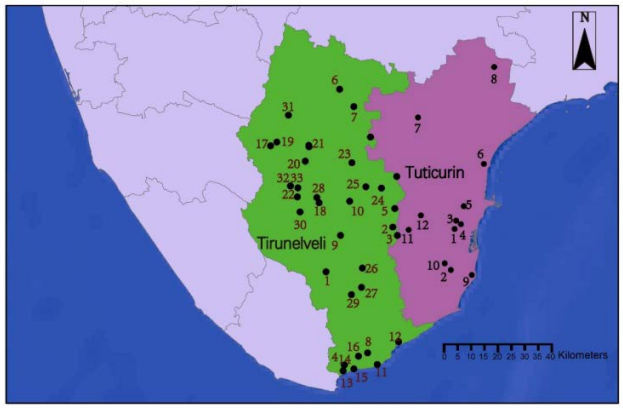

Figure 3. Present distribution locations of Madras Hedgehog *Paraechinus nudiventris* in Tirunelveli and Tuticurin districts of Tamil Nadu, India. Each districts name is labelled on the map while numbers denote areas mentioned in the Table 2 and 3. All the locations retrived from positive respondents community interviews in both the districts in between 2016 - 2017.

3. Animal Survey

Distribution and habitat selection of Madras Hedgehog *P. nudiventris* in Tirunelveli and Tuticurin is established through field surveys and community interviews from June 2016 - May 2017. The field work was conducted in different regions of both the districts (Figure 1). The period of field study is about 124 days in eight sites such as Radhapurum dry zones, Gangaikondan grass lands, Tiruchendur urban areas, shrubs of Tuticurin, Ambasamudram Taluk, Nanguneri shrubs lands, Ittamozi red sandy areas and Ottapidaaram. Along with that, 855 responders for community interviews from 90 villages in both the districts were carried out.

4. Method of Study

Among the trapping method, infrared imagery device, footprint tunnels, questionnaires survey and spotlight method are efficient and suitable methods for the hedgehog detection in rural landscapes methods[16]. We have used spot lighting and questionaries' surveys for the study. Sites were selects on the basis of areas with 50% shrubs and 10-20% of grass fields remaining fewer rocky outcrops. Because of the inaccessibility in most of the dry areas in both the districts, our sampling efforts are very less. To estimate the population size in the selected eight areas, apart from day and night transects, burrow

identification and random sampling was applied in the present study. During the day time burrow counts and animal movements and during night time spot light methods was employed with the help of local people. The burrow of the animals, faecal pellets, location of the vegetation, GPS location was taken photographs. The study was also carried out in the urban areas which are not included in the protected areas and reserved forests of the districts.

5. Morphology

P. nudiventris is a spiny one with a larger snout. The maximum size observed was 26 (± 2) mm long. Body weight was around 315 (± 20) g. The dorsal surface of the body is covered with short stiff pointed spines the ventral side with soft white hair. The spines are sharp at the tip and arranged very closely. The spiny body is an adaptation to escape from predators and to withstand extreme changes. The spines are grey or brown at the base and white at the tip. The snout is elongated and pointed. The ear pinnae are pointed up and broad. Ears are extremely sensitive to sound. The eyes are long and protruded out. The nails are short and claw like. Tails are short and stumpy.

6. Distribution and Habitat Preference

Hedgehogs were basically present in small hillocks, shrub dominated areas and a few nearby small mountainous areas (Figure 2). The species occupies the low lands of the both districts and also near the smaller mountains of the extreme northeast Tirunelveli and smaller hillocks, grasslands of Tuticurin.

Hedgehog presence was determined by field survey during day time and spot light surveys at night. There is much difference in hedgehog population between the west to south Tirunelveli and north to south Tuticurin because of the presence of high elevated mountains and

Figure 4. Live Madras Hedgehog *Paraechinus nudiventris* sighted through field work in Tirunelveli and Tuticurin districts **(A)** Radhapurum dry zones dominated by *prosopis juliflora* **(B)** animal in rolled up position in Nakkaneri shrub dominated urban landscape **(C)** rolled position of hedgehog from dry grass and bush dominated Gangaikondan cattle grazing ground **(D)** smooth white hairs on the under belley observed from Vadivalpuram (E) on a late evening after summer in Paruthipaadu grasslands in 2016.

coastal plains. A total of 15 live hedgehogs were sighted during the study period (Figure 3).

7. Supplementary Data

In general, hedgehogs lives in the grasslands, cattle grazing grounds and found mostly scattered in the south east parts of the Tirunelveli and coastal areas of the Tuticurin district like Sathankulam, Tiruchendur, Ottapidaaram. In southern Tirunelveli, the majority of hedgehogs occupied areas with shrubs nearer to water bodies and agriculture fields. In Ambasamudrum Taluk the water runways during the rainy seasons within the dry lands are well suitable for its survival. The altitude ranges from 56 m to 145 m are their normal elevation in these districts. The presence of hedgehogs from extreme north region is uncertain. Also, possibility of species dispersal to nearby districts through the sandy areas from the Tuticurin to Ramanad region is identified.

Table 1. Details of the individual hedgehogs (*P. nudiventris*) confirmed in different areas of Tirunelveli and Tuticurin districts in 2016 and 2017

S. No	Locality	Latitude	Longitude
1	Chelladurainagar, Tirunelveli, India	8.69	77.79
2	Radhapuram, Tirunelveli, Tamil Nadu, India	8.27	77.686
3	Srivaikundam area, Thoothkudi, Tamil Nadu, India	8.619	77.898
4	Kuthirai MuliTheri, Thoothukudi district, Tamil Nadu, India	8.517	78.012
5	Nakkaneri village, Radhapuram, Tamil Nadu, India	8.217	77.671
6	Tiruchendur, Tamil Nadu, India	8.499	78.098
7	Sankarnagar, Thalayuthu, Tirunelveli, Tamil Nadu, India	8.813	77.719
8	Sanganapuram, Radhapuram Taluk, Tamil Nadu, India	8.258	77.797
9	Maharajapuram, Nagercoil, Tamil Nadu, India	8.152	77.571
10	TherkuKarunkulam, Tamil Nadu, India	8.174	77.576
11	Chettikulam, Tirunelveli, Tamil Nadu, India	8.16	77.615
12	Uralvaimozhi, Tirunelveli, Tamil Nadu, India	8.205	77.633
13	Near Idaikal, (Ambai) Tirunelveli, Tamil Nadu, India	8.759	77.463
14	Gangaikondaan, Tirunelveli, Tamil Nadu, India	8.855	77.781
15	Vadivalpuram, near Parapaadi, Nanguneri, Tamil Nadu, India	8.479	77.592

Table 2. Details of the individual hedgehogs (*P. nudiventris*) confirmed in different areas of Tuticurin district through community interviews in 2016 and 2017

1	Srivaikundam area, Tuticurin district, Tamil Nadu, India	8.619	77.898
2	KuthiraiMuliTheri, Tuticurin district, Tamil Nadu, India	8.517	78.012
3	Vaagaikulam, Tuticurin, Tamil Nadu	8.696	78.030
4	Harbourquarers, Tuticurin, Tamil Nadu	8.683	78.050
5	Puthur, Tuticurin, Tamil Nadu	8.748	78.061
6	Tharavaikulam, Tuticurin, India. (near to AM patti).	8.901	78.141
7	Kurumalaistrech, Kovilpatti, Tamil Nadu, India	9.069	77.867
8	Kalugumalai, Tuticurin, Tamil Nadu, India	9.251	78.177
9	Tiruchendur, Tuticurin, Tamil Nadu, India	8.499	78.098
10	Nazarath, Tuticurin, Tamil Nadu, India	8.541	77.986
11	Seydunganallur, Tuticurin, Tamil Nadu, India	8.663	77.835
12	Vallanadu hill area, Tirunelveli, India	8.715	77.884

Table 3. Details of the individual hedgehogs (*P. nudiventris*) confirmed in different areas of Tirunelveli district through community interviews in 2016 and 2017

1	Mylapuram, Ambasamudrum Taluk, Tirunelveli, Tamil Nadu, India	8.757	77.431
2	Reddiyarpatti village, Tirunelveli, Tamil Nadu, India	8.672	77.768
3	Sivanthipatti village, Tirunelveli, Tamil Nadu, India	8.642	77.787
4	Karunkulam, Tirunelveli, Tamil Nadu, India	8.173	77.576
5	Nagalapuram, Tirunelveli district, Tamil Nadu, India	8.739	77.775
6	Sankarancoil, Tirunelveli, Tamil Nadu, India	9.170	77.540
7	Melaneelithanallur, Tirunelveli, Tamil Nadu, India	9.108	77.600
8	Nakkaneri village, Tirunelveli, Tamil Nadu, India	8.217	77.671
9	Kolunthumamalai, Cheranmadevi, Tirunelveli, Tamil Nadu, India	8.642	77.553
10	Sankarnagar, Thalayuthu, Tirunelveli, Tamil Nadu, India	8.813	77.719
11	Guesthouse and staff houses of kudankulam nuclear power plant, Kudankulam, Tamil Nadu, India	8.175	77.712
12	Sanganapuram, Radhapuram Taluk, Tamil Nadu, India	8.258	77.797
13	Maharajapuram, Tirunelveli, Tamil Nadu, India	8.152	77.571
14	TherkuKarunkulam, Tirunelveli, Tamil Nadu, India	8.174	77.576
15	Chettikulam, Tirunelveli, Tamil Nadu, India	8.160	77.615
16	Uralvaimozhi, Tamil Nadu, India	8.205	77.633
17	Kottaankulam, Tamil Nadu, India	8.966	77.273
18	Near Idaikal, (Ambai) Tirunelveli, Tamil Nadu, India	8.759	77.463
19	Surandai, Tirunelvali District, Tamil Nadu, India	8.963	77.418
20	Keelapavoor, Tirunelveli, Tamil Nadu, India	8.911	77.404
21	Surandai, Tirunelvali District, Tamil Nadu, India	8.967	77.418
22	MulliMalai, Sambankulam, Tamil Nadu, India	8.781	77.372
23	Thadiyampatti, Kayatharu, Tamil Nadu, India	8.998	77.670
24	Rastha village, Maanur village, Tirunelveli, Tamil Nadu	8.818	77.654
25	Vettuvankulam, Mukkudal, Tamil Nadu, India	8.765	77.588
26	Ukkirankottai, Tamil Nadu, India	8.905	77.595
27	Gangaikondaan, Tirunelveli, Tamil Nadu, India	8.855	77.781
28	Backside of the teachers training college, Idaikal, Tirunelveli, Tamil Nadu, India	8.779	77.454
29	Vadivalpuram, near Parapaadi, Nanguneri, Tamil Nadu, India	8.479	77.592
30	Near Papanasam, KMTR outside, Tamil Nadu, India	8.727	77.385
31	Kadayanallur, Tirunelveli District, Tamil Nadu	9.076	77.331
32	Surandai, Tirunelvali District, Tamil Nadu, India	8.963	77.418
33	Keelapavoor, Tirunelveli, Tamil Nadu, India	8.911	77.404

Community surveys revealed, hedgehogs can be found between 600-750 m altitudes in the mountain regions located mainly in western ghats range of Tirunelveli.

Our field work conducted in non-protected areas of the two districts. Hedgehogs prefer arid landscapes mainly, but they were also recorded from different habitats like bushes near to the houses, *Prosopis juliflora* dominated shrub lands, near to dried ponds, edges of groundnut fields, cattle grazing fields, hedges, under Palmyra trees, small hillocks, streets and roads within the boundary of dry arid areas[22]. The coastal plains of Southern Tamil Nadu district Tuticurin holds a bunch of viable populations of the Hedgehog.

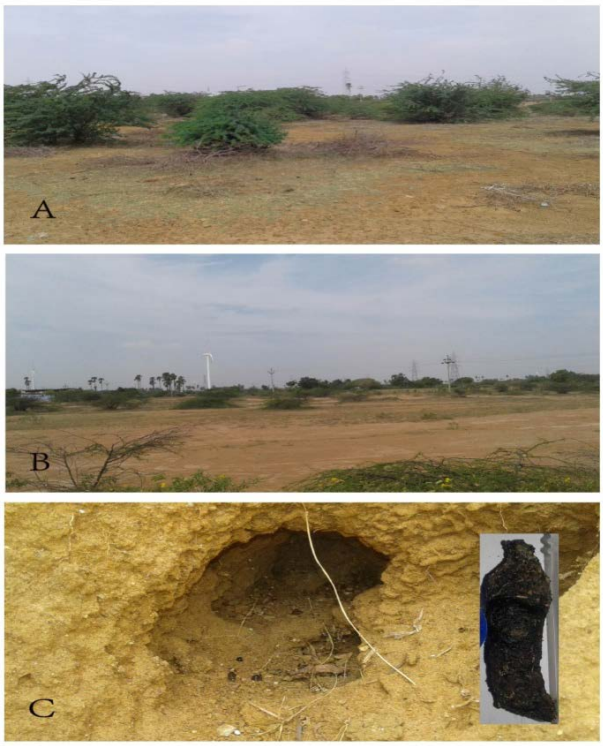

Figure 5. **(A)** The Radhapurum dry zones dominated by *Prosopis juliflora* **(B)** Parapaadi semi- arid zone on the edge of urban landscapes **(C)** an active hedgehog burrow (Naanguneri - dry soil) with a wide opening, intersect figure shows the dried faecal pellet of a hedgehog collected from the burrow in 2016.

In the present study one individual is found in the Theri sand dunes of red soil which is very suitable for the hedgehog near Tiruchendur. Questionnaire surveys revealed that, the red sands are the high sighting areas for bare-bellied hedgehogs. The Paruthipadu grasslands of Tirunelveli district the last remaining grassy patches found to be a good foraging ground for the hedgehogs. The thorny bushes provide them with shelter and protection from the hot sun and predatory animals. While in the case of Daurian hedgehog (*Hemiechinus dauuricus*) in Mongolia, used rocky out crops as a predominate habitat surrounded by shrubs onion grasses and turfy grasses[26]. But recent field[44], studies reported that, *Mesechinus dauuricus* found more in steppe and desert habitats of Ikh Nart Nature Reserve, at Dornogobi Aimag, Mongolia.

Respondents gave positive findings nearby agriculture and water bodies. Thus, the enormous growth of ground invertebrates due to the humidity of dry lands of both the districts with low moisture content is unsuitable for vertebrate population. So, these hedgehogs might have moved towards the wet areas to find the arthropods. The eastern Tirunelveli grasslands and shrub dominated areas are more suitable for hedgehog. In Korea similar findings[17], such as *E. amurensis* is present in wide forests of low altitudes like cultivated regions, forests, grassland, and scrub. They feed on earthworms and other ground invertebrates as well as the occasional small vertebrate and fruit[38].

Thermoregulation is a challenge for hedgehogs which prefer dry areas which avoid daytime activity in order to minimize heat loss. Basking phenomenon has been observed in mammal's species, particularly Ethiopian hedgehog (*Paraechinus aethiopicus*)[5]. The in-active state observed in *P. nudiventris* during the present study might be due to an adaptation to unsuitable conditions. Recently, scientists are focusing on thermoregulation of desert mammals and their ability to minimize heat loss to survive during cold winter. These mammals were able to maximize their heat gain, thus saving energy, when the environmental temperature is substantially lower[38].

8. Description

Hedgehogs are spiny mammals from *Erinaceinae* subfamily of family *Erinaceidae*, with white and very sharp spine at the tip which protects the animal from predators. When the animal is disturbed or when it is in danger it rolls itself into a tight ball which entirely conceals the head, legs and the vulnerable belly, the armory of spines on the dorsal side protecting it. The snout is a little elongated with a mobile pointed snout. The foot is provided with five digits. The nails are short and claw like. The tail is short and stumpy.

9. Characters

9.1 Solitary Habit

Hedgehogs are generally solitary in the wild. The *P. nudiventris* is also a solitary, nocturnal animal, coming out and spends the daytime for sleeping. It comes out in the evening from bushes or shrubs for foraging. In the present study four females and six males with remaining five individuals with sex unidentified. The European male hedgehogs have larger home range than females[33].

9.2 Balling-up

Balling up is a defensive mechanism when they are scared due to any disturbances. The rolling mechanism like a spiny ball is an important adaptation for this mammal. From the head to the back the body is covered with sharp brown colour spines over the dorsal side and the belly is nude with few white soft hairs. The cutaneous muscles are involved in the rolling as a ball (Figure 1).

9.3 Sound Response

Our observation showed that, the hedgehogs are having well developed ears and hearing system. While hunting/ foraging for insects and termites, they depend upon their senses of hearing and smell, because of the poor eye vision that too adapted for vision in night. During the forage sessions, the hedgehogs using smell and sound very effectively than the sight.

9.4 Prey-predation

Size and home range of the hedgehogs directly depends on the food availability[34]. Food availability plays a major role in their distribution of hegdehogs. Foxes, jackal and grey mongoose are found to be the predators. Johnsingh (2001) reported the presence of spines of *P. nudiventris* in the scat of Indian fox in Naanguneri, Tamil Nadu. While examining the faecal pellets, few plants and insect head parts are resulted.

9.5 Diet

P. nudiventris forage for beetles, ants, eggs, earthworms, termites and grasshoppers whereas *P. aethiopicus* major food insects, but[30] study shows that, seed, plant, animal material in the stomach content, includes throated lizard (*Tyodactylus hasselquistii*) in South Africa. This indicates that, this hedgehog is not completely an insectivore mammal. *Hemiechinus dauuricus* in Mongolia feeds, insects as major and birds, rodents and reptiles as minor diet based on scat analysis[26]. In general, the main diet of hedgehog is ground invertebrates[33] but they can eat any kind of large invertebrates[7]. The European hedgehogs forage in very long distances away from their resting burrows. There are some records where South Indian hedgehogs are known to have fought with snakes and mongoose in the wild. Indian naturalist Krishnan (1953) mentioned that they have an ability to survive after snakebites.

Paraechinus micropus and *Hemiechinus auritus* stomach also contains the plant and animal contents which includes elytra of beetles, hard bone parts of amphibian, mammalian skin, dung roller, spine of *H. collaris* and no plant parts were seen[21]. In the case of New Zealand Hedgehog stomachs and scats filled with plant material (Monocot, Dicot, Fungi, Moss and Seed) commonly. And 34 types of invertebrates found along with eggs, passerine birds, hair of mouse. Millipedes and beetles were found as a major diet[7].

9.6 Movement

The hedgehog habitat utilization have a direct connection with food resources and vegetation cover[7]. The daurian hedgehog moved 2 Km per night in search of food in IKH Nart Nature Reserve in Mongolia[26].

P. nudiventris moves fast in the wild but is a slow moving animal under experimental enclosures. This was observed in Radhapurum, Tamil Nadu during the month of February 2017 when they emerged out from their hide and their time of return after active movements for feeding. Similar studies in the case of European hedgehog, which spent 21% of their time on locomotion[33].

9.7 Aestivation

Large chemical energy store in the form of fat is common is all in hibernating animals. Small species that are unable to catch food must therefore reduce energy expenditure during winter by the use of energy saving mechanisms during hibernation[14]. Further there is a less report on the hibernation habit of this mammal during the period of summer season in the study areas of the present study.

The hedgehog in Chelladurai Nagar in Palayamkottai is observed with less weight. This indicates that they are having little hibernating or aestivation tendency. In Danish rural areas, the European hedgehog, losses weight during the May-June, whereas females gained weight[33]. Similar observation is made in the present study from Irukanthurai area in Tirunelveli showed that the hedgehog actively moves around during the night and preys upon insects like ants, termites and beetles. After about 9-10 hours of active foraging it goes back to the shelter around 4 am and come out only in the next evening.

9.8 Adaptation

Our laboratory observations showed that this *P. nudiventris* hedgehog passes small amounts of concentrated urine (yellow) which is also another adaptation to conserve water in a dry habitat. The presence of large number of 10 to 12 mm long narrowly placed spines which are modified hair prevents the direct contact of the skin with the wind thereby reducing the loss of water by evaporation from the body surface. The micro climate found in the shelter under the hedge plants again helps to avoid water loss from the body.

9.9 Heat Basking

Heat gain may contribute to significant energy savings in desert mammals when the ambient temperature is substantially lower than body temperature. Thermoregulation of free ranging Ethiopian hedgehogs (*Paraechinus aethiopicus*) was studied in winter by radio telemetry techniques in semi-arid lands of Qatar[5]. Similar behaviour of hedgehogs was noticed by the present study in *P. nudiventris* in three different places in the study ranges (Nakkaneri, Cheranmadevi and Gangaikondan) in 2016-2017. Hedgehogs generally use three types of nests, such as day nest, breeding nests, and hibernacula[33]. Long-eared hedgehog nests consists of soft soil, sand as their day time nests[29], also they use burrows as maximum, under rocks as moderate and low in base of a tree[35]. Species of the Hemiechinus genus typically use single burrow for their unlined day nests, often using burrows of other species[35].

The present study reported that, villages were surrounded by small barren lands, pasture cattle fields and arable lands which are one of the suitable habitat for hedgehog burrows. The day time nests are in soft soil, under palmya tree leaves. The breeding nests are inside the root of the trees, burrows in shrub dominated areas

Recent research found an evidence of negative climate change impact on almost 700 threatened mammals and bird species[30]. Therefore, it is a high-time to restore habitat within an ecosystem for the conservation globally threatened and indicator species[21,25]. Human-Hedgehog interactions like road kills (97%), natural death due to starvation (56%), bacterial infections Salmonella enteritidis (phage type 20) infections (57%) were reported[32].

Non-random habitat use found in *Erinaceus europaeus* in Danish rural landscapes. This indicated hedgehogs are very flexible in habitat selection[33]. Live *P. nudiventris* was sighted under street tube lights in Akkapurum, Radhapurum, Tirunelveli district. The same kind of observation under street light in nights was recorded for *Paraechinus micropus* and *Hemiechinus auritus* in Rajasthan in India[21].

Some hedgehogs were found in the thorny bushes with the height of 3-5 cm in the dry landscapes and medium sized near grassy patches in Gangaikondan, Tirunelveli during summer and in grasslands of Paruthipaadu in Tirunelveli district. Three hedgehogs were seen in field, as balled up or rolled up position. *P. nudiventris* is found to live in different climatic condition, dry plains, desert terrains and shrub dominated landscapes in Tamil Nadu. The fecal composition of *P. nudiventris* was not completely identified.

10. Conservation of *Paraechinus nudiventris*

Paraechinus genus is with four species with native of North Africa, the Middle East and South Asia. The hedgehogs of the genus *Paraechinus* are unique among the hedgehog with hard spines, and the ability to roll up completely into a ball, protecting the ventral portion of the body. The exploitation of *P. nudiventris* in Ramanathapurum district[40] is found around Varasanadu valley (Hutton, 1949) as a source of food for pets. Also *P. nudiventris* is used by people in southern districts of Tamil Nadu as a remedy for asthma, child care medicines, knee pains and ache[22] which clearly indicates the extensive exploitation of the species for more than hundred years in its range. This ultimately declines the population of this species very fast. The barren land has increased to 10% during the last 20 years and agricultural land is decreased to 9% in sub basin of Thamirabarani River, converting habitats unsuitable for biodiversity.

The hedgehog is a frequent victim of motor traffic in the study areas of present study. Two road kills were reported in 2013, one in Kothapalayam, Tiruppur District and another in Papanasam, Kalakad Mundanthurai Tiger Reserve foot hills, Tirunelveli. There are further sixteen road kills in Radhapuram road, Gangaikondaan road in Tirunelveli District from June 2014 to February 2015 and one in Dharapurum, Erode District in 2014. People often grow this hedgehog as a pet in villages and hedgehog skins were commonly sold in the weekly markets in Southern

India[22]. Also, theses small, spiny-coated Hedgehogs have become popular as exotic species[18].

The status of *P. nudiventris* was urged to upgrade in IUCN Red List from Least Concern to Vulnerable category[40] because of the restricted distribution and ongoing threats. Indian Wildlife Protection Act (1972) listed this hedgehog in Vermin, is a failure in taking steps to conserve its habitats might result in a local and complete extinction of this species in a very near future due to increasing threats. The present study recommends increasing protection of this species through an upgrade from Vermin in IWPA and legislation. Thus Hedgehogs are unique and to lose them would be a devastating indictment of our inability for sustainable livelihood.

11. References

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