RESEARCH ARTICLE

Evaluating the Feasibility of Using Pellets to Assess Age, Relative Abundance and Habitat of Nilgiri Tahr (*Nilgiritragus hylocrius*) in Mukurthi National Park, of Nilgiri Biosphere Reserve, India

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Study Area: Mukurthi National Park, Nilgiri Biosphere Reserve, India

Coordinates: 11°10' to 11°22' N; 76°26' to 76°34' E & 11° 16' N , 76° 32' E.

Key words: Population estimation, Pellet size, Age-Sex structure, Western Ghats

Abstract

The Nilgiri tahr; *Nilgiritragus hylocrius* is an endangered mountain ungulate of India, endemic to two states comes under Western Ghats. It is a social and shy animal found in mixed herds composed of adult and their sub adult young ones. Due to its shy nature and rapid escape tendencies into sharp mountain cliffs the correct population estimation of it is always remain difficult. Thus to make the age-sex estimation of Nilgiri tahr populations feasible, we have used as tools its various sizes of pellets collected from habituated Tahr herd. In the present study, based on pellet sizes about 80% of population were segregated into different age-sex related classes. Result revealed higher overlap in pellet sizes among few age and sex related groups. On the basis of the results the feasibility of using pellet to assess age-sex structure and proper habitat preferred by Nilgiri tahr has been discussed.

Introduction:

One of the recent checklists of the world's extant mammals included 34 species of caprine ungulates. Among such extant caprine ungulates, the Nilgiri tahr has unique distinction of being the only species that is an endemic to the tropical mountains (Daniels, 2006). On the,

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basis of latest molecular phylogenetic research by Ropiquet & Hassanin (2005), the generic position of Nilgiri tahr has been shifted from *Hemitragus* to *Nilgiritragus*. Nilgiri tahr is an endangered mountain ungulate listed in Schedule 1 of the Indian Wildlife (Protection) Act 1972 and categorized as an Endangered by the IUCN (IUCN, 2008). It is the congener of the Himalayan tahr, *Hemitragus jemlahicus*, exists in the range of Kashmir to Bhutan (Schaller, 1971) and the Arabian Tahr, *Arabitragus jayakari*, which is confined to the mountainous areas of Oman and adjoining rocky slopes of Hajar Mountains in United Arab Emirates (Harrison & Gallegher, 1974). Nilgiri tahr is a social animal found in mixed herds composed of Saddle back males, Light brown males, Adult females and their young ones. Montane grassland at an elevation of 1,200 to 2,600 m above sea level is the most favourable habitat for this animal (Rice, 1990; Mishra & Johnsingh, 1998; Kannery, 2002). The present distribution extends from the Nilgiris (in the North) to the Asambu hills (in the South) in the Western Ghats in which Eravikulam National Park, Grass hills in Anamalai and Mukurthi National Park holds the viable population. The climate of this region is very wet with approximately 4 m of precipitation recorded in every year (Rice, 1990).

Earlier the total population was estimated between 2,000 and 2,500 individuals and was thought to be stable (Davidar, 1978; Rice, 1990). However, Daniels *et al.*, (2008) estimated the existing population was nearer to be 1,800-2000 individuals in this complete zone. Population of tahr here is small and isolated, making them vulnerable to local extinction. Habitat patches for Nilgiri tahr are naturally discontinuous, though the anthropogenic pressures are the only cause behind it. The species faces competition from domestic livestock. The principal threats are habitat loss mainly from domestic livestock, spread of invasive plants, poaching (Daniels *et al.*, 2008) and also the illegal hunting. Further, continual conversion of tahr habitat to agricultural land has also been considered as one of the major threat for its declination (Mishra & Johnsingh, 1998; Kannery, 2002; IUCN, 2004).

Nilgiri tahr is of interest from the perspectives of ethology, ecology and conservation, but its survey is quite difficult. Till date major information on its habits and biology were mostly confined to hunting accounts and description on prey-predator relationship. Rice (1984) was the first to make an extensive study on the some ecology and ethological aspects of Nilgiri tahr. It is a very shy animal, which is the main reason for arduous to us to detect and observe it. Tahr is largely confined to steeper terrain having open grassland interspersed in the upper elevation and also in sholas (stunted evergreen forest) or dense forests at the lower elevation which is also a major difficult factor for assessing their distribution, age structure and relative abundance. Thus employing an alternative method is always fruitful to estimate such

Herd of Nilgiri tahr

Pellets of Nilgiri tahr

parameters. Ideally, if indirect evidence such as pellets characteristics could be used to establish their presence, relative abundance and age structure, then it would simplify the process of monitoring the population. Currently there are several constraints in using this approach. First there is no data or information on the feasibility of detecting pellets in different habitat types used by Nilgiri tahr and also on the ability to differentiate between different size classes of Tahr while using their pellets. In addition, the defecation rates and decomposition rates would also be important if we wish to estimate densities, indirectly using the dung count method. The ability to detect pellets as indirect evidence in the tall grass which is a significant part of the Tahr habitat is always critical.

The present piece of work was carried out in Mukurthi National Park of Nilgiri Biosphere Reserve, India which is indeed a pilot attempt to provide the wildlife wardens a baseline to understand the population structure of Nilgiri tahr in a better way and facilitate better monitoring where extensive and intensive field work is not possible.

Materials and Methods:

Study Site: The study was done (January to April, 2010) in the Western Catchments-III part of the Mukurthi National Park, Tamil Nadu, India. This is a well suited zone for Tahr habitat reserved for the protection of this species with an area of 78 km². The park is a part of “Nilgiri Biosphere Reserve”, which is India's first ‘International Biosphere Reserve’. The whole of the Mukurthi national park is under consideration by the UNESCO World Heritage committee for considering as a World Heritage Site (ANON, 1989). This area is also famous for its one of the highest rainfall zone of South India and is an important water catchment area for Tamil Nadu. The western edge of the Nilgiri receives over 5000 mm of rainfall in a single year, in some years rainfall recorded twice this amount, making the slopes of Mukurthi one of the wettest spots in the world. The elevation varies from 1450 m to the maximum of 2629 m (Kolaribetta, the tallest peak). Winters are bright, clear and cold. Hoar frost covers the grasslands at night. The temperature drops from a balmy 25°C at noon to below freezing before dawn. Frost followed by bright sunlight interspersed with cloud cover in a single day imposes severe stresses on plant and animal species.

The park is a home to an array of endangered wildlife, including Royal Bengal tiger, Indian elephant, Nilgiri Marten, Nilgiri langur and Bonhote's Mouse, but the most concerned mammal is Nilgiri tahr. It has also an unique collection of flora, *Strobilanthes kunthianus*, a small shrub blooms once in a twelve years, covering the hillsides with bluish flowers, giving the Nilgiris its name (nil-blue; giri-hill). It is particularly common along the edges of the sholas, as is Rubus (Wild raspberry). Iodex plant (*Gaultheria fragrantissima*), *Rhodomystus tomentosa*, *Rubus* spp., *Rhododendron arboretum*

Forms of Nilgiri tahr: Our study was based on various age-sex structure related classes of the tahr. The age-sex structure of the population was done on the basis of the method described by Schaller (1971) and Davidar (1978) modified by Rice (1984) as per in Table-1

Table-1 : morphological characteristics based age-sex discrimination in Nilgiri tahr.

Status Type	Age	Body Colouration	Horn shape and size	Height structure
Lamb/Young	0-1 years	grey-brown or light coat brown	up to 7cm in length	maximum 45cm height at shoulder
Yearling	1-2 years	grey-brown coat	maximum upto 12 cm in length	intermediate in size between young and adult females
Adult female -2yrs (AF-2)	+ 2 years	grey brown coat, carpal patch black	slender maximum upto 30 cm	height at shoulder 70-80cm
Adult female -3yrs (AF-3)	+ 3 years	dark grey coat; carpal patch black	slender and more than 30 cm	height at shoulder 80- 90cm
Light brown male (LBM)	2-4years	coat color is light brown; at least half if carpal patch is white in color	horns thicker	slightly larger and stockier than adult females distinguished by presence of penis sheath and scrotum
Dark brown male (DBM)	4-5 years	grey-brown to dark brown coat, carpal patches is white in color whereas saddle patch is yet to appear.	horns and body size is greater than those of females	larger and more robust than adult females
Saddle Back (SB)	+ 6 years	dark brown coat with an area of light brown/ white/ silvery hair covering the lower back; rump and/or flanks; carpal patches white.		

Nilgiri tahr pellets and their characteristics: The tahrs' pellets are greenish black in color and cylindrical in shape having rounded bottom (width 1) with the pointed apical region (width 2). Pellets were usually found in tall grassland areas. In the present study, pellets of various sizes from the studied area were gathered and dried up. Further measurements were taken using vernier-caliper and tabulated to confirm their homology to the size classes of the animal. The pellets were collected, measured and characterized as per the age and sex classes of the targeted animal found throughout the entire study area.

In the present study our first target was to assess whether the obtained sample would be identified and counted as pellet groups or need to be counted as an individual pellets in the targeted area. Due to the tall grass it was quite obvious that the ability to segregate the samples as pellet groups might be limited and confusing as the pellets were supposed to get dispersed. Further, to assess the detectability of pellets both plots and strip transects methods were used. We took randomly total 67 strip transects in the study area each of which was of 10 m x 1 m at every 50 meters interval. Detectability was gauged by a slow walk throughout the plot where each sighting of pellet was recorded carefully. Within that pellet group, individual pellets were also recorded and simultaneously a systematic ground search

was made to detect the remaining pellet groups. The second search involved searching closely to the ground by moving grasses to look under. This allowed us to determine the detection probability and also the feasibility of using this method.

Statistical analysis: For probability distribution of tahrs' pellets the multivariate-hypothesis test with regards to the multivariate analysis of variance (MANOVA) was employed. The same was further followed by Wilks's lambda distribution test.

Observation and Results:

Results have been explained in the table 2 & 3 and Figure 2 to 3.

Classification of pellets collected from wild: As there was overlap among the age classes Adult female_2yrs, Adult female_3yrs and Light brown male, these three age classes were merged together for better segregation (Fig.-1). The pellets collected from wild (unknown age classes) were given prior age classes based on the pellet lengths. Pellet length value derived from known age sex classes used for classification of wild pellets is given in Table 1.

Table 2: Classification of age-sex classes of Nilgiri tahr based on the pellet length

Age-sex classes	Length (mm) size class
Lamb/Young	8-10
Yearling	10-11.5
Adult Female_2yrs, Adult Female_3yrs and Light Brown Male	11.5-13.5
Dark Brown Male	13.5-14.5
Saddle Back	14.5+

i) **Size and class of Tahr and its correlation with the respective pellet sizes:** Three variables (length, width1 and width 2) of each collected pellet of Nilgiri-tahr were used in Multivariate Discrimination Function Analysis (MANOVA). All the variables with lowest Wilk's Lambda value were included in the analysis (Table 3).

Figure 1: Pellet length & width2 collected from wild showing the different age-sex classes

Legend: Lamb; Yearling male; Yearling female; Adult female- 2yrs.; Adult female-3yrs.; Light brown male; Dark brown male; Saddle back

Figure. 2a: Mean pellet length of different age-sex classes of Tahr

Figure. 2b: Mean pellet width1 of different age-sex classes of Tahr

Figure 2c: Mean pellet width 2 of different age-sex classes of Tahr

On the basis of above criteria the following segregations were obtained (Fig. 1a,b,c).

Table 3: Results of Wilk's Lambda

Test of Function(s)	Wilks' lammda	Chi-square	Df	Sig.
1 through 3	0.02	2817.48	21.00	0.00
2 through 3	0.83	139.62	12.00	0.00
3	0.98	14.97	5.00	0.01

Wilk's lambda showing significant discrimination of different age-sex classes using the 3 variables. The variables ordered by absolute size of correlation, length, width 1 and width 2 showed the highest group correlation 90%, 70% and 94% respectively. The correlation value between variables is given in Table 4.

Table 4: Correlation value between the variables
(The variables Width 2 and width 1 are function 1 and length is function 2)

Variables	Functions		
	1	2	3
WIDTH_2	0.94*	0.03	-0.33
WIDTH_1	0.69*	-0.43	0.58
LENGTH	0.22	0.90*	0.38

Overall 80% of different age-sex classes were segregated into different classes. There is higher overlap between the Adult female_2yrs Vs Light brown male and Adult female_3yrs Vs Dark brown male.

The accuracy of separation of these age-sex classified ranges from 51% for Adult female_2yrs to 65% for Dark brown male and 74% for Light brown male. For assessing population structure where the primary objective is to identify breeding populations as opposed to all male groups the above methods would be sufficient to determine if there is a breeding group present in the survey area. Additionally it would be possible to get a coarse idea of the age-sex structure of the population (80% accuracy). The only problem would be a slight overestimation of the Adult female class due to inclusion of some Light brown male and Dark brown male into the Adult female (2 and 3 year) classes.

This inaccuracy may be partially overcome by using known errors as shown in this analysis and also possibly by further separating using the two width categories to separate the initial grouping which uses all three measures.

The multivariate discriminate analysis was used to discriminate the different age-sex classes. Eight age-sex classes with 765 individual measurements were used for analysis and measurements of length, width 1 and width 2 were used to segregate (Fig-3). The age-sex classes that show overlap are visible as also those that show little or no overlap in sizes. As already mentioned the male and female yearlings cannot be separated easily while there is overlap between Light brown male and Adult female_2yrs and Adult female_3yr.

The age-sex classification was tested using multivariate discriminate analysis to see how many individual pellets were correctly classified in different age-sex classes. All the 3 variables, length, width 1 and width 2 were used in this analysis.

Finally, overall 97% pellet groups were correctly classified into different age-sex classes. Greater overlap between the DBM and SB was evidenced. The age sex classes were correctly classified (>96%) in Adult female, Dark brown male, yearling and kid. With the pooling of Adult females and Light brown male the separation was 97% which is very good even though we do not know how many Light brown males are there in the population and hence how many adult females. There would be means of further refining the age-sex structure by looking at a range of distributions (for Adult female and Light brown male) in different populations and than using the mean or the range to estimate the possible number of Adult female and Light brown males in the sampled population.

As per expectation the percent grass cover, habitat (open or closed) and the actual number of pellets/pellet groups were all gave significant impact in contributing the detection of pellet groups.

The correlation of these variables to the detectability of pellet groups is given in Table - 5. The pellet group detectability has positively been correlated with actual number of pellet groups and actual number of pellets in the transects. There was a negative correlation between percent grass cover and the detectability of pellet groups (57%) i.e., with an increase in grass cover reduction in detectability of pellets was revealed. Habitat is a categorical variable for 1 closed 2 is open, thus open habitat was evidenced for greater chances of detectability and thus it shown a positive correlation.

Figure-3: Multivariate discriminate function analysis showing the differences in the age-sex classes of Nilgiri Tahr pellets

Figure 4: Relation between the grass availability (%) and pellet group detectability

Figure 5: Relation between the actual number of pellets groups and pellet group detectability.

Figure 6: Relation between the actual number of individual pellets and pellet group detectability.

Table 5: Correlation (r) value for pellet group detectability and various variables

Variables	Number of Pellet group detected	Actual number of pellet groups	Actual number of pellets	Percent grass (%)	Habitats
Number of Pellet group detected	1 *	0.98	0.59	-0.57	0.56
Actual number of pellet groups	0.98	1 *	0.51	-0.56	0.54
Actual number of pellets	0.59	0.51	1 *	-0.30	0.24
Percent grass (%)	-0.57	-0.56	-0.30	1 *	-0.87
Habitats	0.56	0.54	0.24	-0.87	1 *

*Not significant at 0.05 level

Table 6 Regression showing factors responsible for pellet group detectability

Model	Parameters	Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.
Pellet group detectability	(Constant)	-0.37	0.82		-0.45	0.65
R ² =(97%)	Actual number of pellet groups	0.67	0.02	0.89	28.67	0.00
	Actual number of individual pellets	0.01	0.00	0.13	4.81	0.00
	Percent grass cover (%)	0.00	0.01	0.00	-0.01	0.99
	Habitats	0.25	0.31	0.04	.81	0.42

Table 7. Anova to investigate relation between the pellet group detectability and variables (actual number of pellet groups, actual number of individual pellets, percent grass cover and habitat)

Model	Parameters	Sum of Squares	df	Mean Square	F	Sig.
Pellet group detectability	Regression	489.88	4	122.47	459.40	0.00
	Residual	15.73	59	0.27		
	Total	505.61	63			

Figure-4 revealed a negative correlation between percent grass cover and number of pellet groups detected. Further, Fig-5 and Fig-6 evidenced the most significant contributors to detection were the presence of pellet groups and pellets; there is a strong positive correlation between detection and the number of pellet groups/pellets. This is logical as without pellet groups/pellets there would be no detectability. To find out the individual effect of the above factors on detectability of pellet groups 'multiple regression analysis' was also done (Table-6).

The above four variables contribute 97% to the detectability of Nilgiri tahr pellet groups percent (Table - 6 & 7). The actual number of pellets groups, and actual number of pellets had a significant effect on the detection of pellets. In the presence of actual pellet groups and actual number of pellets the other two variables, habitat and grass cover, turned to be non significant. This is a logical correlation as pellets/pellet groups can only be detected if they are present in the plot. In order to remove their effect, these variables were removed in the model, to see the effect habitat and percent grass cover (%) in the detection of pellets groups. That model showed 34% contribution of pellet detectability. The model was significant and beta value for grass cover was -0.36.

Discussion:

Three established techniques for the potential monitoring of relative abundance of animals especially for ungulates; track/trail counts, pellet group counts and transect counts. The present study was carried out to evaluate the feasibility of using pellet to assess the age structure and relative abundance of Nilgiri tahr. Although the outcome may not give an accurate estimation of the actual composition of the animal, but it allow the wildlife wardens to better understand their population structure and facilitate better monitoring where extensive and intensive field work is not possible. Earlier works on this aspect were largely confined to some short term surveys where the data generation were only based on direct citations of the animal. There is need for further investigations to assess the feasibility of assessing age-sex classification of Nilgiri tahr populations using pellets. Nilgiri tahr is a shy animal which do not allow easy observations. Approximately 20% of the 436 Nilgiri tahr observed directly during a WWF survey (unpublished report, 2009) where classification on different age-sex classes were not became possible, hence 80% accuracy obtained using pellets is reasonably satisfactory to determine the age-sex structure of the population subject to this being supported by uniform defecation rates (and decomposition rates for pellets) for different age-sex classes. Differential defecation rates can throw data off when using indirect methods to estimate age-sex structure of a population. This has been shown in case of estimating the age structure of an elephant population using dung sizes; differential defecation rates resulted in incorrect estimation of the population age structure (Daniel *et al.*, 2009).

For researchers and managers it then becomes important that grass cover be treated as the most important variable to be addressed as the presence of pellets is not a certainty in any unknown area being surveyed. It would then require that the search effort be higher in areas with greater grass cover especially if Tahr densities are supposed to be low. So identifying small populations using small areas covered with good grass would need significant effort to detect the presence of Tahr pellets.

Factors like diet, climate variations and available habitat definitely influence the pellet sizes for the same age-sex class in the same and in different areas. Similarly physiological state of the animal could also influence the pellet size. Unfortunately, due to constraints of time such aspects could not be studied in the following piece of work. However, if this method would be used in the field for assessing Nilgiri tahr then a more detailed study covering all aspects potentially influencing pellet sizes have to be considered. There are also factors like defecation rates which could potentially vary among age-sex classes and which too could influence how age-sex structure of the population is determined. Further, there would be a need for larger sample sizes to ensure that the method is robust enough to detect the changes that allow classification of the age-sex classes. Differences in defecation rates and their influence on estimating the age structure of elephant populations has been well established by Daniel, *et al.*, (2009), where it has been revealed that calves and juveniles tend to get underestimated when using this indirect method.

In the present state, the basic data on the exact distribution of the Nilgiri tahr is lacking.

The ongoing survey by WWF India (Nilgiri tahr Report-WWF India; 2009) has identified several populations that were not recorded in the earlier surveys. Most of the earlier reports were based on some quick single sweep surveys covering large areas and hence missed several populations. Under such circumstances pellets were used only as indicators of tahr presence. As Tahr live in mixed sex herds and as bachelor herds, it becomes important to identify such areas which are used by males and/or by females. Often males uses such areas that are not ever used by females as they need smaller space. Further, our results also evidenced that more the area covered with grass the less will be the chances of detecting pellets. The pellet group detectability decreases with increase in grass cover. So for conservation and management it becomes very important to identify such areas used by herds (including the breeding areas) to frame proper conservation strategies for Nilgiri tahr.

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