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Seasonal Variation in Population Density of Sus Scrofa (Wild Boar) Across Habitats in Achanakmar Tiger Reserve, Chhattisgarh, India

Sandhya Kaushik[1], Dr Manoj Singh[2]
[1]PhD Scholar, Department of Zoology, Kalinga University, Naya Raipur, Chhattisgarh-492101
[2]Associate Professor, Kalinga University, Raipur, Chhattisgarh

Abstract
Wild boar (Sus scrofa) is an adaptable, widely distributed ungulate, and estimating how its density varies across seasons and habitats is relevant to prey-base monitoring and management in tiger reserves. We describe seasonal and habitat-wise variation in estimated wild boar density in Achanakmar Tiger Reserve (ATR), Chhattisgarh, India, across five habitat types (grasslands, mixed forest, Sal forest, teak plantations and bamboo forest) and three seasons (post-monsoon, winter and summer). The habitat-wise seasonal mean density rose from 3.76 individuals/km² in the post-monsoon season to 4.56 individuals/km² in winter and 4.96 individuals/km² in summer, and the same ordering appeared in every habitat. Average density was highest in grasslands (5.437 individuals/km²) and mixed forest (5.350 individuals/km²) and lowest in bamboo forest (2.690 individuals/km²); mixed forest had the highest group density (2.500 groups/km²). ANOVA indicated seasonal differences within all five habitats ($p = .0059$ to $.0473$). The causes of the seasonal pattern, whether changes in resources, movement or detectability, were not tested directly. These estimates provide a baseline for monitoring wild boar in ATR.

Keywords: Wild Boar; Sus Scrofa; Population Density; Seasonal Variation; Habitat; Distance Sampling; Achanakmar Tiger Reserve; Chhattisgarh

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Introduction
The wild boar (*Sus scrofa*) is among the most adaptable large mammals, occupying a wide range of habitats and feeding on a broad array of foods. Plant material makes up roughly 90% of its diet in both native and introduced ranges, and food availability and season are major drivers of what it eats (Ballari & Barrios-García, 2014). In Europe, boar numbers have grown steadily (Massei et al., 2015), and its rooting and wallowing alter soil, vegetation and aquatic habitats, with both costs and benefits for other species (Baruzzi & Krofel, 2017).

In Indian tiger reserves, wild boar matters largely as part of the prey base. Tiger density tracks prey abundance (Karanth et al., 2004), and prey assessments in Sariska, Pench and Panna have therefore treated ungulate density as a central variable (Avinandan et al., 2008; Biswas & Sankar, 2002; Gopal et al., 2010), as has work in human-dominated landscapes (Harihar et al., 2014). Wild pig is among the ungulates taken by tigers in Chhattisgarh, where tigers also lean heavily on livestock when wild prey is scarce (Basak et al., 2020, 2025). Reliable boar density estimates are therefore relevant both to predator conservation and to the management of human wildlife conflict.

Forest ungulate densities are rarely constant through the year. In Panna Tiger Reserve, seasonality significantly shaped the distribution and density of four ungulates, including wild boar (Gupta & Krishnamurthy, 2023), and a study in Kanha evaluated how human use, habitat and season affect ungulate densities (Awasthi et al., 2016). Seasonal resource pulses are plausible in Achanakmar as well: the vegetation types of the Achanakmar–Amarkantak landscape differ in seasonal litterfall, with teak plantations producing more than the other types studied (Thakur et al., 2022). Apparent seasonal change can also arise from shifts in detectability and survey conditions rather than from real changes in numbers.

Achanakmar Tiger Reserve lies in Chhattisgarh within the Achanakmar–Amarkantak landscape, a tropical forest region where vegetation structure and forest condition shape conservation planning (Darro et al., 2020; Singh et al., 2024; Thakur et al., 2019). Human activity also influences the reserve and its surroundings (Mahato & Singh, 2022), and human population growth is a recognised pressure on ungulate communities worldwide (Berger et al., 2020), which makes systematic monitoring relevant to management.

Distance sampling is the standard approach for estimating density while accounting for imperfect detection (Buckland et al., 1993, 2001; Thomas et al., 2010), and it has been widely applied to large herbivores in Indian tropical forests (Jathanna et al., 2003; Karanth & Sunquist, 1992). Its estimates depend, however, on the detection function, truncation, sampling effort and model selection (Borchers

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& Cox, 2017; González et al., 2017; Howe et al., 2019). This study focuses on wild boar alone. Duan (2024) We describe seasonal density estimates for the post-monsoon, winter and summer seasons, compare average density across five habitat types, and report group density and group size separately from individual density.

Objectives

1. Estimate and compare wild boar density in the post-monsoon, winter and summer seasons.
2. Compare average density among mixed forest, Sal forest, bamboo forest, teak plantations and grasslands.
3. Report the tests of seasonal variation in density within each habitat.
4. Report group density and group size separately from individual density.
5. Highlight the methodological constraints that bear on interpreting these estimates.

Research Methodology

4.1 Study area and habitats

Achanakmar Tiger Reserve (ATR), Chhattisgarh, India, forms part of the Achanakmar- Biosphere Reserve landscape, where forest composition and vegetation structure have been described in several studies (Darro et al., 2020; Singh et al., 2024; Thakur et al., 2019). Five habitat categories were recognised: mixed forest, Sal Forest, bamboo forest, teak plantations and grasslands. Seasonal variations in density of *Sus scrofa* (Wild Boar) in different habitats of Achanakmar Tiger Reserve, (ATR), Bilaspur Chhattisgarh from 2025 to 2026.

4.2 Study species and variables

The focal species was the wild boar (*Sus scrofa*). We report individual density (individuals/km²), group density (groups/km²), mean group size, effective strip width and AIC values. Individual density and group density are distinct response variables and are presented separately.

4.3 Survey and estimation procedure

Density was estimated with distance-sampling methods (Buckland et al., 1993, 2001). The survey output includes sampling effort, number of observations, observations retained after truncation, density estimates with their uncertainty, effective strip width, and a half-normal model with simple polynomial adjustment, as in line-transect analyses run in the program Distance (Jathanna et al., 2003; Thomas et al., 2010). AIC values are reported in Table 4, bearing in mind that AIC tends to favour overly complex models when distance data are overdispersed (Anderson et al., 1994; Howe et al., 2019) and that estimates can be sensitive to model selection (González et al., 2017). Where sighting-based surveys are impractical in dense forest, dung or sign counts offer an alternative route to density (Adhikari & Khadka, 2009; Ahrestani et al., 2018; Gopalaswamy et al., 2012); the estimates reported here are from distance sampling. A total of 125 transect lines were established across five habitats in Achanakmar Tiger Reserve during 2025–2026; individual transect lengths and detailed observer protocols were not specified in the available records. Darbar et al. (2023) Density estimation was performed using distance-sampling methods in DISTANCE software (version 7.4), with a stated truncation distance of 2.5 km and candidate models compared using AIC. Goodness-of-fit diagnostic results were not available and require confirmation from the original software output.

4.4 Statistical analysis and data handling

Values were transcribed from the survey output tables. The habitat-wise seasonal means (Table 1) and the pooled seasonal estimates (Table 4) are presented separately because their post-monsoon values differ (3.76 versus 4.03 individuals/km²). Seasonal differences within each habitat were tested by ANOVA, and the F statistics and p values are reported as obtained. The seasonal and habitat-wise density data were analysed using ANOVA; however, the sample sizes, degrees of freedom, and exact model structure were not specified in the available records. Model assumptions, including residual normality, homogeneity of variance, and independence of observations, should be checked and documented before interpreting statistical significance.

Results and Discussion

5.1 Seasonal variation in estimated density

Habitat-wise seasonal mean density was highest in summer (4.96 individuals/km²), followed by winter (4.56) and post-monsoon (3.76) (Table 1; Figure 1). The summer mean is about 32% higher than the post-monsoon mean. This is a descriptive contrast and does not by itself establish a cause.

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Table-1. Seasonal variations in density of ***Sus scrofa*** **(Wild Boar)** in different habitats of Achanakmar Tiger Reserve, (ATR), Bilaspur Chhattisgarh from 2025 to 2026.

tHabitat	Post-monsoon	Winter	Summer	Reported average
Mixed forest	4.89	5.35	5.81	5.35
Sal forest	3.81	4.76	5.38	4.65
Bamboo forest	1.91	2.95	3.21	2.69
Teak plantations	3.39	4.15	4.46	4.00
Grasslands	4.78	5.56	5.97	5.44
Reported seasonal mean	3.76	4.56	4.96	4.43

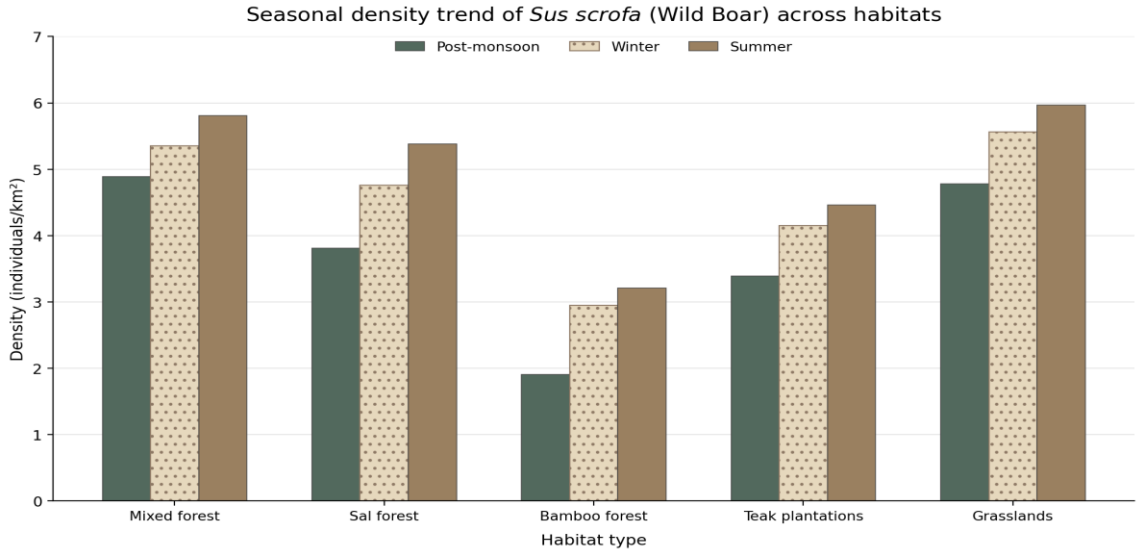


Figure 1. Reported seasonal mean density of Sus scrofa (Wild Boar) in Achanakmar Tiger Reserve. Uncertainty intervals were not available for these means.

The ordering summer > winter > post-monsoon held in every habitat. The highest habitat–season estimate was 5.97 individuals/km² in grasslands in summer, and the lowest was 1.91 individuals/km² in bamboo forest after the monsoon. Porwal et al. (2023) Several processes could produce this pattern, and none was tested directly. Boar diets are dominated by plant material and shift with season and food availability (Ballari & Barrios-García, 2014), and forest-floor resources in the Achanakmar–Amarkantak landscape vary seasonally (Thakur et al., 2022). Seasonality was likewise a significant determinant of ungulate density, including wild boar, in Panna (Gupta & Krishnamurthy, 2023). Dense post-monsoon vegetation may also lower detectability, which would depress estimated density without any change in numbers (Buckland et al., 2001).

5.2 Habitat-wise average density

Grasslands had the highest average density (5.437 individuals/km²), followed by mixed forest (5.350), Sal forest (4.650), teak plantations (4.000) and bamboo forest (2.690) (Table 2; Figure 2).

Table-2. Density and group density of ***Sus scrofa*** **(Wild Boar)** in different habitats of Achanakmar Tiger Reserve, (ATR), Bilaspur Chhattisgarh from 2025 to 2026.

Habitat	Average density (individuals/km²)	Group density (groups/km²)
Grasslands	5.437	1.873
Mixed forest	5.350	2.500
Sal forest	4.650	2.080
Teak plantations	4.000	1.303
Bamboo forest	2.690	1.070
Reported average	4.425	1.765

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Reported SD	1.131	0.580

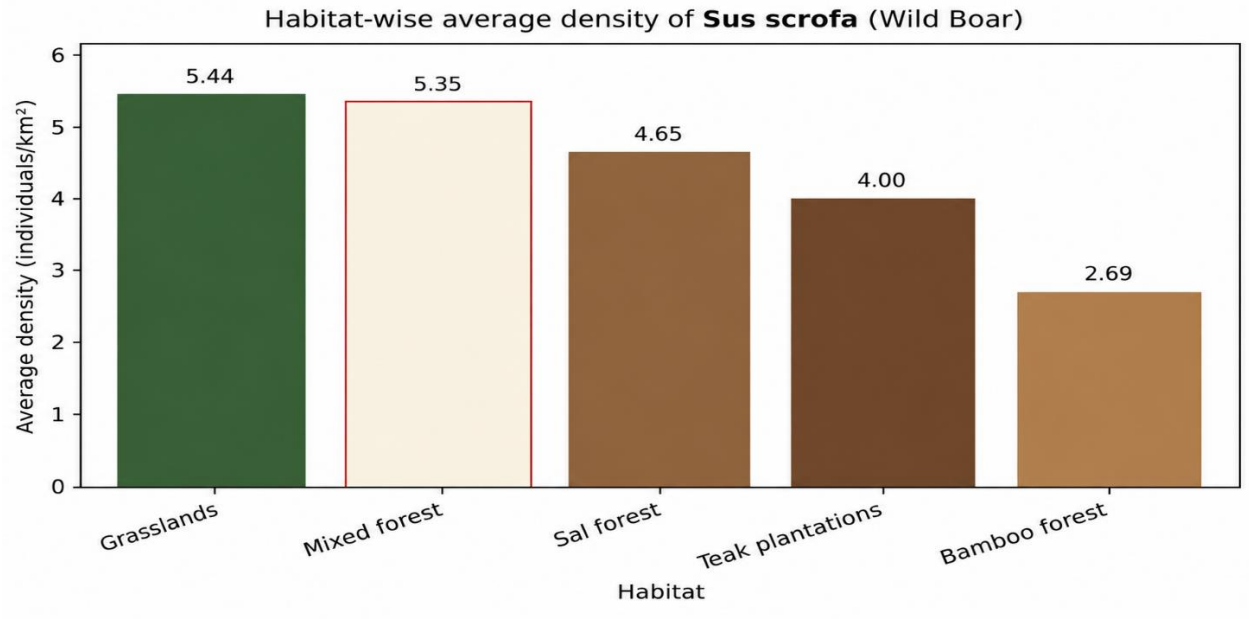


Figure 2. Reported average density of Sus scrofa (Wild Boar) by habitat. Standard errors were not supplied for these habitat averages.

Group density ranked the habitats differently: mixed forest had the highest group density (2.500 groups/km²) and bamboo forest the lowest (1.070). A higher density estimate does not by itself demonstrate habitat preference, which requires information on habitat availability and on how sampling effort was allocated among habitats. Habitat contrasts of this kind are common in tropical forests; in Nagarahole, for example, wild herbivore biomass was lower in dry deciduous forest than in moist deciduous or teak-dominated forest (Karanth & Sunquist, 1992). The mean densities reported here (Table 1) are of the same order as the 4.2 wild pigs/km² recorded in Nagarahole (Karanth & Sunquist, 1992) and well above the 0.4 wild pigs/km² reported for Mudumalai (Ashokkumar & Nagarajan, 2023), although differences in method, season and habitat limit direct comparison.

5.3 Reported statistical tests

Table-3. Density of ***Sus scrofa*** **(Wild Boar)** of Achanakmar Tiger Reserve, (ATR), Bilaspur Chhattisgarh across different habitats and seasons from 2025 to 2026.

Habitat	F statistic	Reported p value
Mixed forest	9.085	.0059
Sal forest	7.399	.0108
Teak plantations	5.282	.0266
Grasslands	4.206	.0463
Bamboo forest	4.167	.0473

ANOVA gave p values below .05 in all five habitats (Table 3), which, if the test assumptions hold, indicates seasonal differences in estimated density within each habitat. The evidence is strongest in mixed forest (F = 9.085, p = .0059) and weakest in bamboo forest (F = 4.167, p = .0473), the latter close to the conventional threshold. The original ANOVA output, degrees of freedom and sample sizes still need to be documented. Statistical efficiency and model selection are also important in distance-sampling analyses (Clark, 2016; González et al., 2017; Howe et al., 2019).

5.4 Pooled seasonal estimates and group characteristics

Table-4. Density ((individuals/km²) of ***Sus scrofa*** **(Wild Boar)** in Achanakmar Tiger Reserve, (ATR), Bilaspur Chhattisgarh in different seasons from 2025 to 2026.

Parameter	Post-monsoon	Winter	Summer
Pooled density (individuals/km²)	4.03 ± 1.53	4.56 ± 1.65	4.96 ± 1.80
Pooled group density	1.56 ± 0.26	1.76 ± 0.35	1.82 ± 0.47

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(groups/km²)			
Mean group size	2.58 ± 0.94	2.59 ± 0.89	2.72 ± 0.73
Effective strip width (m)	22.55 ± 2.60	37.70 ± 4.75	35.00 ± 4.50
AIC	215.87	229.35	247.28

Note. Values are shown as reported in the survey output. The supplied results explicitly describe the ± values for density, mean group size, and effective strip width as standard errors (SE). For example, density is reported as \(4.03 \pm 1.53\) individuals/km², and the text refers to the associated uncertainty as a standard error .The pooled post-monsoon density (4.03 individuals/km²) differs from the habitat-wise mean in Table 1 (3.76 individuals/km²); the reason for this difference should be stated.

In the pooled estimates, summer had the highest density (4.96 individuals/km²), group density (1.82 groups/km²) and mean group size (2.72). Mean group size changed little among seasons (2.58 to 2.72) compared with group density (1.56 to 1.82), so the seasonal rise in individual density in these data comes mostly from more groups rather than larger ones. Effective strip width was 22.55 m after the monsoon, against 37.70 m in winter and 35.00 m in summer, so detection conditions differed between seasons; the narrower post-monsoon strip may reflect reduced visibility and is a reason to treat the post-monsoon contrast with some caution (Buckland et al., 2001). AIC values are model-comparison measures rather than measures of abundance (Anderson et al., 1994).

Conclusion

Wild boar density in Achanakmar Tiger Reserve showed a consistent seasonal pattern: the habitat-wise seasonal mean was highest in summer (4.96 individuals/km²), intermediate in winter (4.56) and lowest in the post-monsoon season (3.76), and the same ordering appeared in every habitat. Grasslands (5.437 individuals/km²) and mixed forest (5.350) held the highest average densities, bamboo forest the lowest (2.690), and mixed forest the highest group density. These estimates add to the prey-base information available for the reserve, in a region where wild prey depletion has pushed tigers towards livestock (Basak et al., 2020, 2025).

Several limitations apply. Uncertainty intervals are not available for the habitat means, the ANOVA sample sizes and degrees of freedom are not yet documented, and the pooled and habitat-wise post-monsoon estimates differ (4.03 versus 3.76 individuals/km²). Because seasonal differences in detectability can mimic changes in abundance, repeated seasonal surveys with a fully documented estimation procedure will give the most reliable picture, and such baselines are a precondition for evaluating any future management of wild ungulate populations (Barton et al., 2022).

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