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Efficiency of Fixed-Width Transect and Line-Transect-based Distance Sampling to Survey Red Junglefowl (*Gallus gallus spadiceus*) in Peninsular Malaysia

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Abstract

Reliable survey method is very important to estimate wildlife population. In this study, fixed-width strip- and line-transect samplings were simultaneously used to yield population estimates on oil palm plantation. The latter was found to be more accurate but less precise than the former based on the Per cent Relative Bias (hereafter PRB). Using the strip-transect, an overall density and abundance were estimated at 0.3237 birds/ha and 3 018 ± 273 birds (CV = 9.05%), respectively. An unbiased overall density generated by line-transect, D ± S.E. = 0.500 ± 0.069 birds/ha (95% CI: 0.38137 - 0.65521) and estimated total abundance, N ± S.E. was 4 661 ± 644 birds (95% CI: 3 556 - 6 109; CV = 13.81%) for the entire 9 323.53 ha study area. The former and latter method gave relative and absolute estimates, respectively.

Keywords: Density, Abundance, Fixed-width strip-, Line-transect, Per cent Relative Bias

1. Introduction

Density and abundance are the essential ecological information required for population ecology. The scope of ecology covers distribution of organism and its abundance (Buckland, 1993; 2001). And estimating the abundance has been a challenge in wildlife science because many previous surveys used indices to estimate relative abundance (Rusk, 2007). The managers and biologists have to consider the most cost-effective way to survey a population and later come out with very reliable estimates in order to apply them in the management. New survey techniques are well developed today and some are inexpensive and without physical contact with study animal. One of them is Distance Sampling which was introduced and refined by several statisticians (Buckland, 1993, 2001; Burnham, 1980). Unlike all the simple indices, Distance Sampling fits a detection function to the observed distances in order to estimate the proportion of objects missed by the survey (Thomas, 2002). In the absence of complete census, Distance Sampling is a reliable survey method available to produce useful information.

Wildlife resource management in Peninsular Malaysia is improving through active law enforcement and engagement with stakeholders but still lacks the science. Poaching was encountered seriously and prosecuted illegal hunters were fined for the wildlife crime they committed (DWNP 2006). One good example is in term of gamebird management which still needs better scientific based management. Not only the gamebirds are exploited with liberal hunting quota but the population size has never been surveyed to determine its status. Red junglefowl (hereafter RJF) or *Gallus gallus spadiceus*, is evaluated as being of Least Concern in the IUCN Red List. In Peninsular Malaysia, it is a game-bird species protected under the Wildlife Protection Act 76 (1972). Previous studies on the species in Malaysia was pioneered by Abdullah and Babjee (1982) and later followed by Arshad (1999) through several publications (Arshad & Zakaria, 1999; Arshad, 2000a, 2000b; Zakaria, 2003). Population density of RJF in Malaysia is poorly studied and not available in publication, especially before 1999. Globally, a paucity of survey efforts deters any management development of population levels to harvest the species in sustainable way. Main literature written by naturalists such as Delacour (1977) and Johngards (1999) never addressed the significance of oil palm plantation as the main habitat for RJF in Southeast Asia.

The main objective of this study was to determine the efficiency of fixed-width transect and line-transect-based Distance Sampling in estimating the density and abundance of RJF on palm oil plantation. This study also evaluated the precisions offered by coefficient of variation (CV) in estimates of density generated by fixed-width strip and line transects sampling.

2. Methods

2.1 Study Area

This study was conducted in Carey Island, located on the west coast of Peninsular Malaysia, in the state of Selangor (Latitude: 101º 16'E - 101º 27' E, Longitude: 2º 48'N - 2º 59'N). Mean daily air temperature was 29.08 ± 0.07 º Celsius from 1st of May to 31st of August 2006 (Subang Weather Station of Malaysia Meteorological Department). Surveys were carried out for four months consecutively (May - August 2006) at different dates (2nd - 6th May; 12th - 16th June; 24th - 27th July; 28th - 31st August). Geographically, the island is separated from the mainland by the Langat River, and the landscape was predominantly cultivated with oil palm. The island is a completely low lying area and defended from the intrusion of seawater by artificial barriers. The major landowner was Sime Darby Plantation, a government-linked investment company. The plantation of 11 509.36 ha has been divided into management divisional areas, namely, West estate and East estate with 5 199.53 ha and 5 229.59 ha, respectively. The plantations covered more than 77% of the whole land area (approximately 15 000 ha). The plantations can further be divided into mature (> 4 years old oil palm) and immature, accounting for 9 323.53 ha and 1 105.59 ha, respectively.

2.2 Survey Design and Implementation

Twenty-one transect lines, or tracklines, ranging from 0.5 to 2 km in length were covered on foot in the study. The tracklines were located separately at > 200 m to avoid double counting of individuals. Our survey work was limited to four to five days in each month, as permitted by the plantation management - which provided logistic assistance. The tracklines were set up randomly in straight lines on the loading road, and marked using a Global Positioning System. These tracklines were considered spatial replicates and repeated every month. The loading road are the road within every plantation block, they are generally in straight lines either oriented in a north-south or east-west direction.

Two observers traversed the tracklines on foot. Each observer was assigned to the left or right side of the transect line. Daily data collection of approximately four hours started from 0730 to 1230 hrs – with work suspended through the early afternoon. The surveys resumed for another four hours from 1500 to 1900 hrs. In this study, we assumed that an aural detection represented 4 birds/flock as every crowing sound from an unseen male signifies its territoriality and controlled harem.

The perpendicular distances between the transect line and the initial location of RJF were measured directly with a digital rangefinder. The geometric centre of a cluster was determined to be the centre point of the flock from the trackline (Buckland, 1993, 2001). The observers marked the nearest oil palm tree to the RJF and walked until to a point which paralleled the point where the RJF was first spotted. This method seemed to be more practical, instead of using the triangulation method.

2.3 Fixed-width Strip Transect

For strip transect surveys, data were analyzed by month and over the whole hunting season. The total numbers were estimated using the equation suggested by Greenwood and Robinson (2006), specifically designed for unequal sample areas. The formulae incorporated the relationship between the samples and the whole study area from which they were drawn. In a finite number (M) of potential sampling units, the sampling fraction (m/M) was used to calculate the standard error and the confidence limits of the mean. In this case, m is considered the actual sample. The sampling unit or site is defined as a standard grid of one km^2 on a topographic map. The calculation used to estimate population size for the fixed-width strip transects sampling is outlined as below:

D = estimated density of RJFs per unit area (ha) = $\sum_i n_i / \sum_i a_i = n_i/A = n_i/2WL$,

N = estimated total number in the N sites = A x D,

var (N) = $[var(n) + (D)^2 var(a) – 2(D)cov(an)]M^2(1- m/M)/m$,

Standard error of estimated N = $\sqrt{var(N)}$,

where M = total number of sites comprising the study area, A = total area of these sites, m = number of sites sampled, a_i = area of the i th site, n_i = numbers of RJF on the i th site, W = half-width of the strip transects, and L = length of the transect.

In this case, m was calculated as m = $\sum$(Strip Area) ha x 1 km^2/100 ha = 4.256 km^2

The sampling fraction was computed as m/M = 4.256 km^2/93.235 km^2 = 0.0456.

2.4 Line-Transect-based Distance Sampling

The RJF densities and abundances were estimated using the Conventional Distance Sampling engine of DISTANCE 4.1, Release 2 (Thomas, 2003), where each line was used as sampling unit and by selecting the model that best fits the data (Burnham, 1980). A scatter graph of the cluster size s_i against the x_i distance was plotted to check any size-biased problem. Pearson correlation was used to determine any relationship between cluster size and distance.

Five models were selected as key functions, together with its series expansion (Half-normal + Cosine; Half-normal + Hermite; Uniform + Cosine; Uniform + Polynomial; Hazard-rate + Cosine). Final model was selected on the lowest value of the Akaike's Information Criterion (hereafter AIC). The AIC identified the best model that fits the data well, and does not have too many parameters (Buckland, 1993, 2001). Ungrouped data in the form of measured perpendicular distances were analyzed. The perpendicular distances of each RJF from the transect line were recorded. All the RJFs located on the line were detected with certainty, the densities of RJF clusters in the area surveyed (D) were estimated. The parameter f(0), corresponds to the probability density function of the perpendicular distances, evaluated at zero. The parameter f(0) is also interpreted as 1/μ, where μ is termed the effective strip half-width and, when multiplied by 2L, gives the effective area surveyed. If one animal was detected then it was assumed that the whole flock was detected (Thomas, 2002). To obtain the estimated density of individuals, the previous equation was multiplied by an estimate of mean cluster size in the population, E(s):

$D = n \times f(0) \times \hat{E}(s))/2L$

The variance of estimated density which comprised three components was calculated as outlined by Buckland et al. (1993, 2001):

$\text{Variance}(D) = D^2 \times \{[cv(n)]^2 + [cv(f(0)\}]^2 + [cv(s)]^2\}$

2.5 Comparison between Fixed-width Strip and Distance Sampling-Line-Transect Estimates

In order to compare the estimates between fixed-width strip and line transect, per cent relative bias (PRB) was applied in the study. However, only truncated results of line transects were used in the calculation. Following the same example used by Ogutu (2006), the estimates produced by the line transects are taken to be unbiased, and the strip-transects are taken to be biased because visibility decreases with distance. The PRB is therefore calculated as:

$PRB = 100(\text{Estimated } N_{Strip} - \text{Estimated } N_{Line})/\text{Estimated } N_{Line}$

3. Results

3.1 Relative Estimates by Fixed-width Strip Transect

The fixed-width was defined by the maximum perpendicular distance of detection multiplied by two (strip width = 2W = 2(d_{max}) = 2 x 80 m = 160 m). The maximum distance was based on the aural detections and applied to density calculations. The highest density computed was in July for actual and adjusted count (sample size for bird counted, n_i = 101; density, D_{Actual} = 0.237 and n_i = 146; density, $D_{Adjusted}$ = 0.343, respectively) and the lowest was in August (n_i = 77; D_{Actual} = 0.181 and n_i = 122; $D_{Adjusted}$ = 0.287, respectively) (Table 1). The CVs were calculated around 8-12%. The estimated densities and abundances for adjusted detection were higher than actual detection. The CVs also increased in the adjusted detection due to increase in sample size. Total actual count of RJF for four months was not significantly correlated with sampling area (Pearson correlation = 0.367; P = 0.102) (Figure 1).

3.2 Absolute Estimates by Line-Transect-based Distance Sampling

Over the four months, 170 detections were recorded. Goodness-of-fit test was not significant for spatial and temporal replicates (Table 2), and indicates a good fit of detection function models to the corresponding frequency of histograms of distance data. Population estimates for July in adjusted detection dropped less than estimates in actual detection. Population estimates were all similar (Table 2). Precision (measured in coefficient of precision, CV) were around 22-27%. July was the month with the highest density for actual and adjusted count (sample size for number of detection, n_l = 46; D_{Actual} ± S.E. = 0.555 ± 0.125 birds/ha and n_l = 46; $D_{Adjusted}$ ± S.E. = 0.536 ± 0.121 birds/ha, respectively) and August was the lowest (n_l = 40; D_{Actual} ± S.E. = 0.453 ± 0.112 birds/ha and n_l = 46; $D_{Adjusted}$ ± S.E. = 0.494 ± 0.120 birds/ha, respectively) (Table 2). These results were consistent with the strip transect estimates. Two models appeared to provide the same minimum AIC value for August, and program DISTANCE 4.1 selected one of them at random (Half-normal + Hermite). In contrast, other months used Uniform + Cosine model. The scatter plot shows that many clusters were detected near the line, and visibility diminished further from the line (Figure 2). This was a negative dependence on the distance as the observers successfully spotted larger flocks close to them.

The uniform cosine provided a good fit with the distance data (AIC = 1 397.8; Chi-square, χ^2 = 11.406; d.f. = 11; P = 0.410) for the actual count results. RJF density was estimated at 0.503 ± 0.056 birds/ha (CV of 11.19%). But, for the non-adjusted aural detections the precision was almost similar. Truncation of 10 % data was applied to remove the outliers in order to improve data for modeling. This consequently reduced observations from 170 to 159. This procedure decreased the precision for actual (0.513 ± 0.071 birds/ha; 4 783 ± 657 birds) and adjusted estimations (0.500 ± 0.069 birds/ha; 4 661 ± 644 birds) to 13.74% and 13.81% respectively. Repeated sampling is not a problem in distance sampling method as long as the same individual is not double counted in a given survey (Buckland, 1993, 2001). Temporal replicate is an example way to increase precision. The CVs for overall surveys increased by around 11% compared to monthly estimates.

3.3 Comparison between Fixed-width Strip and Line-Transect Estimates

Strip-transect sampling resulted in lower estimates of RJF abundance than the line-transect sampling based on the negative value of PRB (Table 3). However, the former produced more precise estimation than the latter, both in spatial and temporal replicates. This was consistent with our finding that the strip-transect estimates tends also to be severely biased low relative to line-transect estimates. This result is similar to that of Ogutu (2006). The results showed the distinction between two sampling methods in which fixed width of strip transects yielded higher precision in terms of visibility than variable strip half width of line transect. Noting that the former used a straightforward computation of animal encountered and the latter used detection function of animals encountered and missed during the surveys. The assumption that every animal was counted in the strip plot was defined to be every RJF encountered visually and aurally during the survey, which gave complete counts.

4. Discussions

The cluster or flock density obtained was higher than that of Zakaria (2003). He estimated 0.449 ± 0.026 flocks/ha in the four year old plantation. In contrast, we estimated 0.202 ± 0.025 flocks/ha. For estimated average size of flock, Zakaria (2003) reported that the largest size was 3.06 ± 0.35 birds and 1.88 ± 0.06 birds for four year old and 22 year old plantation respectively. Our result yielded 2.471 ± 0.144 birds/flock. On the other hand, Collias and Collias (1996) reported the average flock size as 11 birds for an introduced free-ranging population in San Diego Zoo, which is about twice the average of five birds per flock they found in India (Collias & Collias, 1967). We disagree with any suggestion that cluster size is limited to less than a dozen per flock in the wild, since we observed as many as 18 birds per flock (male : female = 4:14) in May. Other results by Javed and Rahmani (2000) estimated 1.60 ± 0.11 to 5.70 ± 0.62 birds/flock, but varied according to winter and summer season. The surveys were limited to plantation blocks more than four years old because it was found difficult to walk through plantations of young, thick, and short palms when we tested it during the pilot study. It might be possible to use point transect sampling to survey such thickly vegetated habitat and analyze the data separately. Estimates of point transect and line transect sampling might be combined to provide overall population size. The estimates from line-transect survey produced almost similar abundance and CV. This reflects that a good level of accuracy was achieved in this survey, as suggested by Buckland (1993, 2001).

The line-transect estimates were twice those of the strip transect estimates. Both strip and line transect sampling improved their precision for overall estimates. The overall CVs from both samplings are between 9% and 11%. Aural detections were adjusted to rectify the size bias, which is more important than precision optimization in distance sampling analysis (Buckland, 1993, 2001). Without the adjustment, the estimates are underestimated. One common practice in avian studies using distance sampling to increase n, is repeated sampling (Rosenstock, 2002). Buckland (1993, 2001) suggest that double-counting generally is of little consequence in practice, particularly if such events are relatively infrequent. The distribution of both counts and densities were not normal for certain months (June and July). Greenwood and Robinson (2002) suggested that departure from normality has no effect on the estimations of the means and variances, with an exception for the standard error and confidence limits. The analysis of variance to compare the monthly means of density is fairly robust with respect to the violation of normal distribution assumption.

For PRB, the fixed-width strip-transect estimates showed negative bias in all cases. Therefore, this method underestimated the population densities and abundances. Generally, biases and limitations of index counting procedures have been highlighted (Burnham, 1981; Verner, 1985) and are a matter of great concern, because they are then unable to provide reliable information (Rosenstock, 2002). The point estimate (overall) of RJF density in the Carey Island (0.500 ± 0.069 birds/ha) was lower than the highest density of 0.842 ± 0.055 birds/ha as obtained by Zakaria (2003) in four-year old oil palm plantation, although the CV was not given. The estimates from this study were higher than the estimates for other plantation habitats found by Zakaria (2003). This specific result was obtained from one of his study sites (Sungai Sedu GHP Plantation) less than 15 km from the Carey Island site. This particular plantation was 709.06 ha, which made it only a fraction of 8% of the surveyed area of Carey Island. The estimates from Zakaria (2003) used two tracklines and were repeated twice every month for a year. No monthly estimates were given in that study. Treating each walk as a sample tends to underestimate the variance, rather than pooling data for all walks for a given transect and treating each as true spatial replicate (Jathanna, 2003).

The estimates from Carey Island were more representative for oil palm plantation in Peninsular Malaysia. If stratification was used to analyze the data, it is possible that a higher density can be obtained in certain habitat or area, as demonstrated by Arshad (1999). However, overall estimates were more useful rather than stratification estimates for wildlife managers as they normally did not know much about plantation conditions, especially if it is privately owned. The results of this study reestablished that the density of RJF in oil palm plantation is higher than in primary forest. O'Brien (2000) found the density in heavily and lightly hunted areas were 2.32 and 1.32 birds per 100 ha, respectively in lowland rainforest of Sulawesi, Indonesia. Other early estimations were conservative because of a lack of rigorous statistical analysis and used merely naive estimate calculations. Studies conducted in India provided an estimate of 1.00 birds/ha (Collias & Collias, 1967) and 0.25-0.50 birds/ha (Bump & Bohl, 1961) respectively. These estimates resulted from surveys conducted in semi-natural habitat, but lacked rigorously statistical analysis. Point estimates derived from bird count should have suitable measures of precision (standard error, coefficient of variation, or confidence interval) since otherwise they are of little value (Rosenstock, 2002) and make comparisons difficult (Reading, 1998).

During the four months surveys, only 66 detections were registered as aural. Separate analysis for monthly aural detection would produce imprecise estimates due to small sample size. Therefore it is good practice to combine both visual and aural counts in order to reliably estimate population abundance. Bibby (1992) and Buckland (1993, 2001) suggested a minimum of 40-80 sightings per survey for a precise estimate of density. Based on the field observations, the crowing males of RJF only moved a little. This situation made it possible for the observers to approach close to the birds even without any sighting. Jiménez (2003) suggested that movement of singing birds seems unlikely to cause significant error in detection distance measures.

5. Conclusion

From this study, the line-transect-based Distance Sampling provided unbiased density and abundance of RJF but less precise than the fixed-width strip transect. The results of the former survey method were more reliable to be applied for decision making process in wildlife management and conservation.

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Table 1. Fixed-width strip transect counts. Monthly count (n_i), variance of count, covariance of area multiplied by count, estimates of density, population abundance, variance of abundance, standard error of abundance, and per cent of coefficients of variation (% CV), by month (May, June, July, August), and over the whole open hunting season.

Replicates	Month	Detections	Sample size, n_i	var (n)	cov (an)	Density [A] (birds/ha)	Abundance [B] (N ± S.E.) (no. of bird)	Var (N)	% CV [C]
By month (21 lines/month) [D]	May	Actual	87	34.83	22.240	0.2044	1 906 ± 235	55 437	12.33
		Adjusted	138	56.56	26.480	0.3242	3 023 ± 300	90 016	9.92
	June	Actual	88	19.16	12.667	0.2068	1 928 ± 180	32 513	9.34
		Adjusted	145	43.79	14.907	0.3407	3 177 ± 283	80 173	8.91
	July	Actual	101	22.26	0.213	0.2373	2 212 ± 224	50 291	10.13
		Adjusted	146	30.75	2.853	0.3430	3 198 ± 266	70 933	8.32
	August	Actual	77	20.03	10.213	0.1809	1 687 ± 190	35 944	11.26
		Adjusted	122	35.16	11.173	0.2867	2 673 ± 258	66 411	9.65
Combined (84 lines) [E]	Overall	Actual	353	23.37	10.924	0.2074	1 934 ± 205	41 948	10.60
		Adjusted	551	40.27	13.353	0.3237	3 018 ± 273	74 364	9.05

[A] Naive density = no. of bird detected/area

[B] S.E. (N) = $\sqrt{Var(N)}$

[C] %CV = 100% x [(S.E. of Density)/Density]

[D] var (a) = 64.60

[E] var (a) = 62.26

Table 2. Sample size of combined detections (visual and aural) (n_1), number of RJF sighted per km (n/L), expected cluster (or flock) size [E(S)], cluster (DS) and individual density (D), population abundance (N), and its per cent of coefficients of variation (%CV) for Carey Island based on program DISTANCE 4.1, release 2 software.

Month	Sample size, n_1	Detections[A]	(n/L)	E(S) (no. of bird)	DS ± S.E. (flocks/ha)	D ± S.E. (birds/ha)	N ± S.E. (no. of bird)	%CV [B]
May	36	Actual	1.3534	2.7996	0.1636 ± 0.0370	0.4581 ± 0.1226	4 271 ± 1 143	26.76
		Adjusted	1.3235	3.2603	0.1600 ± 0.0369	0.4950 ± 0.1359	4 864 ± 1 360	27.96
June	48	Actual	1.8045	2.2124	0.2315 ± 0.0514	0.5121 ± 0.1229	4 775 ± 1 146	24.00
		Adjusted	1.8045	2.3453	0.2315 ± 0.0514	0.5429 ± 0.1339	5 062 ± 1 249	24.67
July	46	Actual	1.7293	2.6177	0.2120 ± 0.0423	0.5549 ± 0.1249	5 174 ± 1 165	22.51
		Adjusted	1.7358	2.5209	0.2128 ± 0.0423	0.5364 ± 0.1209	5 001 ± 1 127	22.54
August	40	Actual	1.5038	2.1903	0.2069 ± 0.0465	0.4532 ± 0.1122	4 226 ± 1 046	24.76
		Adjusted	1.5038	2.3862	0.2069 ± 0.0465	0.4938 ± 0.1196	4 603 ± 1 115	24.22
Overall	170	Actual	1.5977	2.3081	0.1933 ± 0.0188	0.4461 ± 0.0495	4 159 ± 462	11.11
		Adjusted	1.5977	2.6009	0.1933 ± 0.0188	0.5027 ± 0.0562	4 687 ± 524	11.19

[A] Results from actual count were warned because of size bias adjustment has increased expected cluster size.

[B] %CV = 100% x [(S.E. of Density)/Density] = 100% x [(S.E. of Abundance)/Abundance]

Table 3. Summary of the coefficients of variation (CV) of line and strip transect estimates of population abundance, and the per cent relative bias (PRB) of the strip transect estimates of abundance relative to the corresponding line transect estimates.

Replicates	Month	Detections	% CV(Strip)	% CV(Line)	PRB
Spatial	May	Actual	12.33	26.76	-55.37
(21 tracklines)		Adjusted	9.92	27.96	-37.85
	June	Actual	9.34	24.00	-59.62
		Adjusted	8.91	24.67	-34.68
	July	Actual	10.13	22.51	-57.24
		Adjusted	8.32	22.54	-36.05
	August	Actual	11.26	24.76	-60.09
		Adjusted	9.65	24.22	-41.93
Temporal	Overall	Actual	10.60	11.11	-53.50
(21 tracklines x 4 times)		Adjusted	9.05	11.19	-35.61

Table 4. Estimates of density and abundance of RJF produced by previous studies and this study.

Study/Area	Sampling method	Habitat	Individual density (birds/ha)	Flock density (flocks/ha)	Flock size (birds/flock)
Bump & Bohl (1961), India	Naive estimate	Mixed evergreen forest	0.25 to 0.50	n.a.	n.a.
Collias & Collias (1967), India	Naive estimate	Sal forest	1	n.a.	5
Collias & Collias (1996), San Diego Zoo, USA	Naive estimate	Semi-feral population	13.4	n.a.	11
O'Brien *et al.* (2000), Sulawesi	Line transect (4 tracklines)	Lowland rainforest	0.015	n.a.	n.a.
Javed & Rahmani (2000), India	Line transect (6 tracklines)	Sal forest Mixed forest Riparian forest Teak forest Grassland Forest-grassland	n.a.	n.a.	2.40 ± 0.11 [A] 2.50 ± 0.10 [A] 1.80 ± 0.36 [A] 2.50 ± 0.26 [A] 1.60 ± 0.11 [A] 2.50 ± 0.17 [A]
Arshad (1999), Zakaria *et al.* (2003), Malaysia	Line transect (2 tracklines in each habitat except for fruit orchard)	Oil palm plantation [B] Rubber plantation Fruit orchard	0.842 ± 0.055 0.061 ± 0.087 0.157 ± 0.036	0.449 ± 0.026 0.043 ± 0.062 0.083 ± 0.015	1.88 ± 0.06 1.40 ± 0.24 1.89 ± 0.26
This study	Strip transect Line transect (21 tracklines)	Oil palm plantation [C]	0.324 0.500 ± 0.069 [D]	- 0.202 ± 0.025	- 2.471 ± 0.144

n.a. = information not available

[A] Mean flock size (± S.E.) from summer observation.

[B] Plantations of 4-year old growth.

[C] Overall estimates.

[D] 10% truncation.

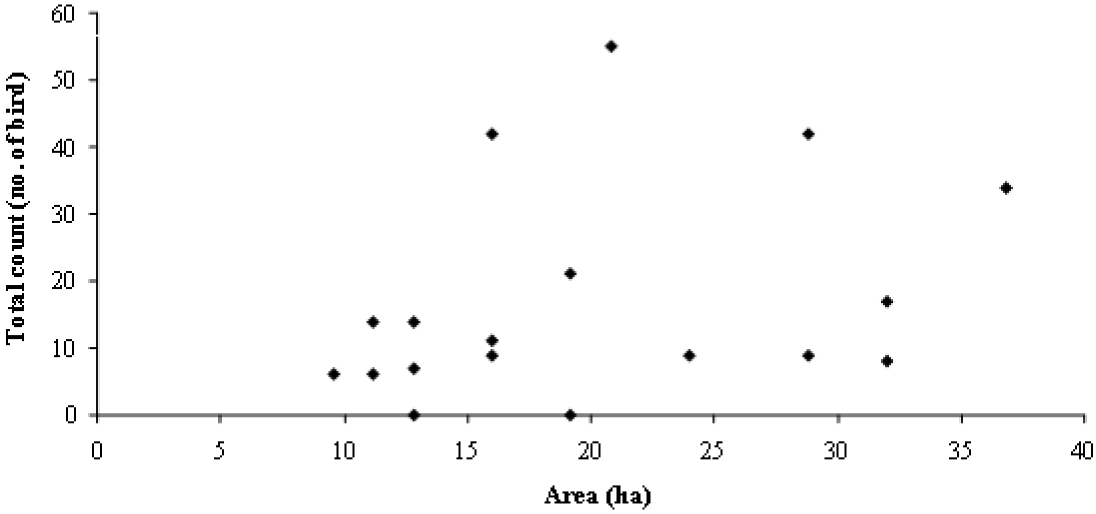

Figure 1. Total actual count of RJF for four months detected on 21 fixed-width strip transects of various sizes. More birds were detected in strip areas between 16 and 36.8 ha than strip areas between 9.6 and 16 ha.