Wildlife Session

Line Transect vs. Capture-removal Estimates of Bobwhite Density

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Abstract: We compared estimates of northern bobwhite (*Colinus virginianus*) density derived from line transect (LT) and capture-removal (CR) sampling with each other and with 2 independent indices of abundance (coveys flushed/party-hour of hunting and captures/100 trap-sets). CR estimates were not correlated with either index ($P \geq 0.371$), whereas LT estimates were correlated with captures/100 trap-sets ($P = 0.009$) and not with coveys/party-hour ($P = 0.156$). Although CR and LT estimates were not correlated ($P = 0.288$), the estimators gave similar ($P > 0.05$) estimates of density in each of 4 years of study, and estimates differed by <22% in 3 non-drought years.

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Line transect (LT) sampling of northern bobwhite density has been evaluated on rangeland (Guthery 1988). Bobwhites appear to be behaviorally compatible with transect sampling. However, transect estimates of density rarely have been compared with estimates from other techniques or with indices of abundance. Shupe et al. (1987) reported that LT estimates for bobwhites based on data collected from helicopters and ground walking were similar to a Lincoln-Petersen Index in 1 year of study.

Capture-removal (CR) methodology has received wide use in bobwhite research (Kellogg et al. 1970, 1972; Dimmick et al. 1982; O'Brien et al. 1985). The usual approach is to mark birds through trapping and banding and to sample the proportion marked in the population through shooting. The Lincoln-Petersen Index, or a modification thereof, serves as the estimator of population size.

The comparative performance of LT and CR methods in estimating bobwhite density remains largely unexplored. Such information is useful for workers selecting

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among methods of enumerating quail. We compare density estimates derived from LT and CR sampling, and we compare the respective estimates with 2 independent indices of abundance.

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Methods

Data were collected from October 1984 through March 1987 on 4,800 ha of the Jennings Ranch in Zapata County, southern Rio Grande Plains of Texas. About 20% of the ranch is a relatively open honey mesquite (*Prosopis glandulosa*) motteland on deep sands (Shupe and Beasom 1987:552). The remaining 80% is mesquite-mixed brush with a moderate to dense canopy on sandy loams. About 50% of this latter community is in 1- to 10-year-old regrowth following discing.

Trapping took place annually from September through early November with collapsible, funnel-type traps (Smith et al. 1981) baited with grain sorghum. We set traps at existing feed and water stations before sunrise or about 2 hours before sunset, and checked them within 2 hours. Captured quail were fitted with Size 3 or 3A leg bands supplied by the Texas Parks and Wildlife Department.

Recaptures were based on hunter-shot samples collected during November–February. Hunters (2–4) rode modified pick-up trucks which followed a dog until it pointed. Coveys and singles were then pursued on foot.

We used the Bailey mark-recapture model (Seber 1973:61) to estimate population size and its variance. Estimated variance may have been biased low because of sampling coveys (O'Brien et al. 1985). Density was estimated as population size divided by the ranch area surveyed. The standard error of the density estimate was the standard error of the population estimate divided by the ranch area surveyed (see Burnham et al. 1980:22).

We believe assumptions underlying the CR estimator generally held. Population closure was approximated because data collection took place outside of the breeding season and the study area was large relative to the mobility of quail, thereby minimizing the effects of ingress or egress. Trap sites occurred throughout the ranch to insure mixing of marked and unmarked individuals. The method of recapture (shooting) was independent of the method of capture, thus eliminating effects from trap response. However, we had evidence (unpubl. data) that juveniles were more vulnerable to harvest than adults ($P = 0.008$). This heterogeneity in recapture probabilities could impose a slight negative bias on the Bailey estimate. We had no evidence that females were more vulnerable to harvest than males ($P = 0.204$), contrary to the findings of Pollock et al. (1989). We had no reason to suspect loss of bands over the ≤ 6 months of recapture, and the band reporting rate was 100%.

Transect sampling occurred in the central portion of the ranch during September–October; total length of sampling lines was allocated in approximate proportion to soil types. Sampling on sandy loams consisted of 4 1.6-km lines spaced at 137-

m intervals and on sands consisted of 4 0.8-km lines at the same spacing. Lines were marked with plastic flagging at 10- to 15-m intervals. Lines were walked within 3 hours after sunrise or 3 hours before sunset. A transect line was sampled only once during morning and evening periods, but lines were walked repeatedly over time, which is legitimate in transect sampling (Burnham et al. 1980:19). The total distance walked each year was 64 km.

The Fourier series detection model was used to estimate density of coveys because this model is robust and efficient (Burnham et al. 1980) and adequately describes flushing behavior of bobwhites in a variety of settings (Guthery 1988). Bird density was estimated by multiplying covey density times mean covey size. Burnham et al. (1980) detailed estimation of variance of bird density and Guthery (1988) gave examples specific to quail.

Assumptions underlying LT sampling generally hold for bobwhites on rangeland (Guthery 1988). In particular, we felt that we observed all coveys on or near the transect line, lateral movement away from the line in response to the observer was minimal, and perpendicular distances from the transect line to the point of flush were measured accurately because we used tape measures. We also searched each flush site to insure detection of all members of a covey. There was evidence that coveys on our area were not distributed randomly (Guthery 1988); therefore, estimated variance may have been too low.

Two indices of abundance also were calculated for comparison with LT and CR estimators. The first was the mean number of coveys flushed per party-hour of hunting (1 hunting party hunting for 1 hour). This mean was based on 3–4 months of hunting within a given season. Hunting effort was 244 party-hours in 1984, 407 in 1985, 454 in 1986, and 230 in 1987. The second index was the number of quail captured per 100 trap-sets, where a trap-set was 1 trap operative for 1 morning or 1 evening period.

We hypothesized that the absolute and relative estimates of abundance would be positively correlated. We tested this hypothesis by determining the significance of Pearson correlation coefficients based on 1-tailed t-tests.

Results and Discussion

Sample size (N coveys flushed) approached or exceeded the recommended number of 40 (Burnham et al. 1980) in 3 of the 4 years (Table 1). The sample size was low in 1984 because drought prevailed and quail density was low.

The total trapping effort ranged between 1,171 trap-sets in 1984 and 210 in 1987 (Table 1). This effort resulted in the banding of from 133 to 516 birds and recovery of from 6 to 95 banded birds based on shot samples ranging from 567 to 1,968 birds (Table 1).

The CR and LT estimators differed in their relationships with the independent indices of abundance (Table 2). Density based on CR was not correlated with coveys/party-hour ($r = -0.15$, $P = 0.575$) nor with captures/100 trap-sets ($r = 0.26$, $P =$

Table 1. Sampling effort for line transect and capture-removal analysis of northern bobwhite populations in Zapata County, Texas, 1984–1987.

	Line transect			Capture-removal			
	Coveys	Covey size		Trap	Banded and	Banded	Total
Year	flushed[a]	$\bar{x}$	SE	sets	released	recovered	N shot
1984	23	6.3	0.7	1,171	133	6	567
1985	36	10.6	0.8	347	433	95	1,926
1986	66	9.9	0.8	221	516	85	1,968
1987	54	10.9	0.8	210	436	54	1,298

[a]Based on 64 km of walking each year.

0.371). Conversely, LT estimates were not correlated with coveys/party hour (r = 0.69, P = 0.156) but were strongly correlated with captures/100 trap-sets (r = 0.98, P = 0.009). Despite the lack of significant correlations in most tests, LT, CR, and captures/100 trap-sets gave parallel information on population trends in 3 of 4 years (1985–1987) (Table 2).

As expected based on the above results, density estimates from CR and LT sampling were not correlated (r = 0.42, P = 0.288). However, estimates from LT and CR sampling differed by <22% during 1985–1987 and were statistically similar in all 4 years since 95% confidence limits overlapped, although the CR estimate was 2.8 times the LT estimate in 1984.

The CR estimate was of questionable validity in 1984, because it was inconsistent with the other 3 indices. The inconsistency may reflect a relatively low number of birds banded (Table 1) and an unusually low direct recovery rate. This rate was 4.5% in 1984 compared to 21.9%, 16.4%, and 12.3% in 1985, 1986, and 1987, respectively. The low rate in 1984 may have resulted because of sampling variation or because of a poor distribution of marked birds in the population relative to hunting pressure. Also, 1984 was a drought year characterized by a general failure in reproduction and relatively low quail densities.

Table 2. Densities (N/ha) estimated with line transect and capture-removal methods and indices of abundance for northern bobwhites in Zapata County, Texas, 1984–1987.

	Line transect		Capture-removal		Coveys/party-hour		
Year	$\hat{D}$	SE	$\hat{D}$	SE	$\bar{x}$	SE	Captures/100 trap-sets
1984	0.80	0.365	2.25	0.745	1.4	0.11	11.4
1985	1.48	0.113	1.81	0.179	2.2	0.13	124.8
1986	2.68	0.629	2.46	0.258	2.2	0.27	233.5
1987	2.18	0.559	2.15	0.278	3.0	0.20	207.6

Recommendations

Subject to the need for further research, we offer these preliminary recommendations. Workers choosing between CR and LT methods of estimating density or population size of northern bobwhites probably should give most weight to costs, time requirements, and appropriateness to habitat conditions and study objectives. We found the estimators gave parallel information, except in a drought year. In our work, LT analysis was less expensive to conduct than CR analysis (Shupe et al. 1987). Further, LTs gave preseason estimates of population size for planning the forthcoming harvest; such estimates are not possible with CR analysis based on hunter-shot samples. However, LT data are subject to low precision, even with fairly intensive sampling (Guthery 1988).

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