A COMPARISON OF SOME CENSUS TECHNIQUES FOR THE COTTONTAIL RABBIT

by
JAMES R. BRADY
Department of Forestry
University of Tennessee
Knoxville 37916[1]

and

MICHAEL R. PELTON
Department of Forestry
University of Tennessee
Knoxville 37916

ABSTRACT

For comparative purposes four census techniques were applied to livetrapping data from native cottontail (Sylvilagus floridanus) *populations in two beagle field trial enclosures. On both areas the Virginia Polytechnic Institute-Grouped Lincoln Index, the Schnabel and the Schumacher-Eschmeyer methods yielded similar estimates; the Eberhardt method yielded estimates which were approximately double the others. Stocking of rabbits on both enclosures provided populations of known density for testing the accuracy of the estimators. The Eberhardt method showed a tendency to overestimate cottontail populations; however, it was consistently more accurate than the other methods tested. Other evidence which supports the use of the Eberhardt method is discussed.*

Few mammalian studies of wild populations have been reported which compare the performances of various population estimators under conditions which afford controls over population variables. Even fewer have been able to test the accuracies of the estimators. A study of cottontail rabbit populations in large enclosed areas of natural habitat provided an opportunity for such studies. Large enclosures were available in the form of beagle field trial areas. By working within such areas, immigration and emigration were controlled. Because the study was conducted during the period of reproductive quiescense, mortality was the only major uncontrolled factor affecting population density.

By marking cottontails on a study area and then intensively hunting bordering areas, Chapman and Tretheway (1972) found that there was very little movement of rabbits off the study area. It therefore appears that the controls afforded by enclosure fences may not constitute an artificial situation with respect to cottontail populations.

We wish to express appreciation to members of the Smoky Mountain Beagle Club and the Atomic Beagle Club for their cooperation and permission to use their enclosures. This study was supported by funds made available from the Tennessee Wildlife Resources Agency through Federal Aid in Wildlife Restoration Project, Tennessee W-46-3.

STUDY AREA

This study was conducted on two beagle trial enclosures in Knox County, Tennessee. The Smoky Mountain Beagle Club (SMBC) enclosure lies at the foot of one of the numerous ridges of the area. This enclosure covers 12.2 ha and extends from a base elevation of 305 m up the ridge slope to an elevation of about 336 m. Approximately 50 percent of the area is covered by a near-mature second-growth woodland of mixed hardwoods and shortleaf pine (*Pinus echinata*). Principle hardwood species are chestnut oak (*Quercus prinus*), white oak (*Q. alba*), and mockernut hickory (*Carya tomentosa*). The remainder of the area is an early, abandoned field with numerous red cedar (*Juniperus virginiana*) and blackberry (*Rubus* sp.) invading sparse fescue (*Festuca arundinacea*) and orchard grass (*Dactylis glomerata*) areas.

[1] Present address: Florida Game and Fresh Water Fish Commission, 4005 South Main Street, Gainesville, Florida 32601

The Atomic Beagle Club (ABC) enclosure covers 45 ha of a very old alluvial plain of the Clinch River. It can be characterized topographically as steeply rolling with elevations varying between 270 m and 320 m. Only about 30 percent of this enclosure is managed for cottontails. This area is a patchwork of blackberry brambles, feed strips, and planted loblolly pine (*Pinus taeda*). About 45 percent of the enclosure is devoted to cattle grazing. The largest part of the grazed area is dropseed (*Sporobolus* sp.) and fescue pasture. It also contains yellow poplar *(Liriodendron tulipifera)* and white ash *(Fraxinus americana)*, and about one ha of shortleaf pine. The remaining 25 percent of the enclosure is covered by a mature oak-hickory woods interspersed with old clearings which have revegetated to dense growths of honeysuckle (*Lonicera japonica*), and blackberry, and yellow poplar.

The design of the enclosure fence is similar on both study areas. The fence is approximately 1.0 m high and constructed of 17 ga, 5.1 cm hex-mesh poultry fencing. About 30 cm of the fencing is folded inward at the bottom and staked down to prevent rabbits from burrowing under.

MATERIALS AND METHODS

Wooden box traps constructed a 5/8-inch (1.6 cm) exterior plywood were utilized. Using a grid pattern, traps were uniformly distributed at a rate of one trap per acre (0.4 ha). Trap stations were permanently marked. However, as Eberhardt (1969) recommends, each trap was shifted periodically about its respective grid point to insure interaction with all cottontail home ranges.

Four, two-week trapping periods were conducted in each enclosure beginning in September, 1972, and ending in March, 1973. Between the first and second trapping periods, both study areas were stocked with imported cottontails. Seventy-one rabbits were released on the SMBC enclosure and 123 were released on the ABC enclosure 14 days prior to censusing.

All cottontails handled, both trapped natives and imported individuals, were marked with eartags and pelage dyes. Detailed descriptions of marking techniques are given by Melchior and Iwen (1965) and Brady and Pelton (1976).

Four population estimators were applied to the capture-mark-recapture data derived from the study. These were the methods of Schnabel (Overton 1971), Schumacher-Eschmeyer (Overton 1971), Eberhardt (1969), and the V.P.I.-grouped Lincoln Index (Davis 1963).

RESULTS AND DISCUSSION

A trapping effort of 7,335 trapnights on the two enclosures resulted in 293 captures (Table 1). These captures involved 214 individuals and 79 recaptures.

The greatest trapping success occurred on both study areas during the second trapping period conducted between 2 November and 15 November on the SMBC area and between 21 November and 5 December on the ABC area. This appears to have resulted from some behavioral change which improved the probability of capture for many individuals. The number of native individuals captured, increased from 42 in the first trapping period to 60 in the second period. Fifty-five of the 60 individuals were rabbits which had never been trapped. This improved trapability may have been caused by cooling temperatures (Bailey 1969) or a concomitant decrease in food availability (Eabry 1968) and vegetative cover. Average distances traveled between capture sites increased from approximately 82 m during the first period to approximately 112 m during the second period. Janes (1959) found that as food and cover deteriorate with the onset of winter, surviving rabbits must move farther and farther to find adequate food and cover. The stocking of large numbers of rabbits as occurred during the present study may have a similar effect on the movements of native cottontails. Such increased activity would bring the cottontail into contact with more traps thus increasing the individual's probability of capture.

Another change in behavior is apparent from recapture data. Of the 42 individuals captured during the first trapping period only five were recaptured during the second period. This may indicate some degree of trap-shyness acquired through experience with

Table 1. Trapping data for cottontail rabbits by study area and trapping period.

Trapping period	*Date*	*Captures*	*Individuals*	*Recaptures*	*Trap nights*	*Trapping success (%)*
		Smoky Mountain Beagle Club				
1	14 Sept-26 Sept	27	16	11	379	7.12
2	2 Nov - 15 Nov	35	27	8	384	9.11
3	6 Dec - 20 Dec	8	8	0	449	1.78
4	23 Jan - 5 Feb	19	15	4	417	4.56
Subtotal		89	66	23	1629	5.46
		Atomic Beagle Club				
1	4 Oct - 20 Oct	39	29	10	1511	2.58
2	21 Nov - 5 Dec	130	87	43	1362	9.54
3	6 Jan - 19 Jan	26	24	2	1382	1.88
4	13 Feb - 28 Feb	9	8	1	1471	0.61
Subtotal		204	148	56	5726	3.56
Total		293	214	79	7355	3.98

traps as suggested by Eberhardt (1969). However, mortality and changing movement patterns indicated above undoubtedly affected the recapture of individual rabbits.

Table 2 illustrates the population trends on the two study areas as derived by four methods of estimation. Due to insufficient data, estimates by all methods were not possible for every trapping period. During the second trapping period on both areas all estimators indicated a marked increase in population size. This resulted from the introduction of 71 new rabbits on the SMBC enclosure and 123 new rabbits on the ABC enclosure. On the ABC enclosure, the third period estimates by the Schnabel and Schumacher-Eschmeyer methods indicated a continued population increase. A population increase at this point is not possible and is likely associated with the disproportionately

Table 2. Cottontail rabbit densities per hectare[a] by trapping period using four techniques of population estimation.

Method	*Per hectare population estimates*			
	Smoky Mountain Beagle Club Trapping Period			
	1	2	3	4
Schnabel	1.73 (0.70)	5.41 (2.19)	—	2.30 (0.93)
Schumacher-Eschmeyer	1.73 (0.70)	4.47 (1.81)	—	2.67 (1.08)
V.P.I.-Grouped Lincoln Index	2.15 (0.87)	3.61(1.46)	—	2.12 (0.86)
Eberhardt	3.11 (1.26)	10.74 (4.35)	—	5.88 (2.38)
	Atomic Beagle Club Trapping Period			
	1	2	3	4
Schnabel	1.48 (0.60)	3.36 (1.36)	3.80 (1.54)	0.57 (0.23)
Schumacher-Eschmeyer	1.43 (0.58)	3.09 (1.25)	4.67 (1.89)	0.64 (0.26)
V.P.I.-Grouped Lincoln Index	1.26 (0.51)	4.50 (1.82)	—	—
Eberhardt	3.48 (1.41)	5.90 (2.39)	2.59 (1.05)	1.46 (0.59)

[a]per acreage estimates in parenthesis.

low recapture rate experienced during trapping period three. A lack of recaptures during this period on the SMBC enclosure prevented any estimates at all.

On both areas, the Lincoln Index, the Schnabel, and the Schumacher-Eschmeyer methods yielded similar estimates. The Eberhardt method, however, yielded estimates approximately double the magnitude of the other estimates.

The restocking program conducted by the enclosure owners provided an opportunity to compare the accuracies of the four estimators. Capture data from these stocked cottontails were applied to the estimators. On both areas, the Eberhardt method missed the actual number stocked by only two animals (Table 3). The other estimators, duplicating the tendency indicated above, yielded estimates which were only about half the magnitude of this known population change. Recognizing that the time lapse between stocking and censusing was about two weeks in both cases, the Eberhardt estimates were probably high due to expected mortality during that interval.

Another approach for evaluating the accuracies of the estimators was possible. Total population estimates during the first trapping period (before stocking) were compared with total population estimates during the second trapping period (after stocking) (Table 4). The difference between those two estimates provides an estimate of the number of rabbits added. On the ABC area the Eberhardt method yielded an estimate of 109 rabbits stocked. That estimate is 14 less than the number actually stocked, however, considering mortality, it is likely very close to the number present at censusing. On the SMBC enclosure where 71 rabbits were stocked, an estimate of 93 stocked rabbits was derived by this method. This further indicates a tendency of the Eberhardt method to overestimate

Table 3. A comparison of density estimates of two populations of stocked rabbits using four estimators during the second trapping period, 2 November to 5 December, 1972.

	SMBC		*ABC*	
	Population estimate	*Confidence interval (95%)*	*Population estimate*	*Confidence interval (95%)*
Number actually stocked	71		123	
Schnabel estimate	38	14-77	71	40-114
Schumacher-Eschmeyer estimate	31		61	
V.P.I.-Grouped Lincoln Index estimate	28	20-50	45	23-77
Eberhardt estimate	69	61-77	121	65-177

Table 4. Population estimates of stocked cottontail rabbits derived from total population estimates before and after stocking.

	Atomic Beagle Club			*Smoky Mountain Beagle Club*		
	Period 1	*Period 2*	*Stocked population estimate*	*Period 1*	*Period 2*	*Stocked population estimate*
Schnabel	67	151	84	21	66	45
Schumacher-Eschmeyer	64	139	75	21	54	33
V.P.I.-grouped Lincoln Index	56	202	146	26	44	18
Eberhardt	157	266	109	38	131	93

populations. The next closest estimate of stocked rabbits on the SMBC area was 45 rabbits by the Schnabel method.

The population estimators used in the present study are of two general classifications. The V.P.I.-grouped Lincoln Index, the Schnabel method, and the Schumacher-Eschmeyer method are all capture-recapture methods of estimation. The models for these formulae are based on the Poisson distribution (Huber 1962). A basic assumption of capture-recapture models assuming a Poisson distribution is that all members of a sampled population possess equal probabilities of capture (Davis 1963). Studies by Geis (1955), Huber (1962), Eberhardt et al. (1963), Edwards and Eberhardt (1967), and the present study indicate that cottontails have different and changing probabilities of capture. The Poisson distribution also requires that marked animals be allowed to become randomly mixed throughout the population prior to sampling (Cormack 1966) and that sampling itself be randomly conducted (Jolly 1963). Cottontails, however, apparently have definite home ranges (Dalke and Sime 1938) so random mixing of marked individuals is unlikely. Dalke and Sime (1938) also state that cottontail home ranges may vary from 0.13 to 21.6 acres. Therefore, one rabbit would have a greater probability of capture simply through greater contact with traps.

Huber (1962), based on evidence that all rabbits do not have the same probability of capture, stated that the use of estimators assuming a binomial or Poisson distribution should be ruled out in cottontail studies. Edwards and Eberhardt (1967) found that the Schnabel and Schumacher-Eschmeyer methods grossly underestimated cottontail population densities and concluded that they were unsuitable for estimating rabbit numbers.

The Eberhardt method is relatively new and has not been tested widely in the literature. French et al. (1971) and Phillips and Campbell (1970) present evidence that this method is unreliable based on their findings from studies of small rodents and whelks, respectively. French et al. (1971) point out that their census data would fit the model only if many animals were captured once, fewer captured twice, etc. The authors also reason that failure of their data to fit the model might be due to trap density and inherent behavior of the small rodents. We feel these are two factors researchers should consider more seriously in future studies dealing with population estimation of mammals.

In the present study, the Eberhardt method tended to overestimate cottontail populations. However, it consistently yielded the most accurate estimates. Therefore, in light of the severe underestimation of this known population by the other methods used and the preponderance of evidence opposing their use, it is concluded that the Eberhardt method is more acceptable for estimating population densities of cottontail rabbits.

LITERATURE CITED

Bailey, J. A. 1969. Trap responses of wild cottontails. J. Wildl. Manage. 33(1):48-58.

Brady, J. R., and M. R. Pelton. 1976. An evaluation of some cottontail rabbit marking techniques. Tenn. Acad. Sci. 51(3):89-90.

Chapman, J. A., and D. E. Tretheway. 1972. Movements within a population of introduced eastern cottontail rabbits. J. Wildl. Manage. 36(1):155-158.

Cormack, R. M. 1966. A test for equal catchability. Biometrics 22(2):330-342.

Dalke, P. D., and P. R. Sime. 1938. Home and seasonal ranges of the eastern cottontail in Connecticut. Trans. N. Am. Wildl. and Nat. Resour. Conf. 3:659-669.

Davis, D. E. 1963. Estimating the numbers of game populations. Pages 89-118 in H. S. Mosby (ed), Wildlife Investigational Techniques. 2nd ed. The Wildlife Society. Washington, D. C. 419pp.

Eabry, H. S. 1968. An ecological study of *Sylvilagus transitionalis* and *S. floridanus* of Northeastern Connecticut. A report of the Storrs Agric. Exp. Stn. Proj. No. 376, 27pp.

Eberhardt, L. L. 1969. Population estimates from recapture frequencies. J. Wildl. Manage. 33(1):28-39.

Eberhardt, L., T. J. Peterle and R. Schofield. 1963. Problems in a rabbit population study. Wildl. Monogr. 10. 51pp.

Edwards, W. R., and L. Eberhardt. 1967. Estimating cottontail abundance from livetrapping data. J. Wildl. Manage. 31(1):87-101.
French, N. R., C. D. Jorgensen, M. H. Smith, and B. G. Maza. 1971. Comparison of some IBP population estimates for small mammals. Spec. Rept. Office of the Chm., USNC/IBP. 25pp. (Mimeo.)
Geis, A. D. 1955. Trap response of the cottontail rabbit and its effect on censusing. J. Wildl. Manage. 19(4):466-472.
Huber, E. P. 1962. Trap response of confined cottontail populations. J. Wildl. Manage. 26(2):177-185.
Janes, D. W. 1959. Home range and movements of the eastern cottontail in Kansas. Univ. of Kansas Publ. Museum of Nat. History 10(7):553-572.
Jolly, G. M. 1963. Estimates of population parameters from multiple recapture data with both death and dilution-deterministic model. Biometrika 50:113-128.
Melchior, H. R., and F. A. Iwen. 1965. Trapping, restraining, and marking Arctic ground squirrels for behavioral observations. J. Wildl. Manage. 29(4):671-678.
Overton, W. S. 1971. Estimating the numbers of animals in wildlife populations. Pages 403-457 in R. H. Giles (ed) Wildlife Management Techniques, 3rd ed. The Wildlife Society, Washington, D. C. 633pp.
Phillips, B. F., and N. A. Campbell. 1970. Comparisons of methods of estimating population size using data on the whelk. J. Anim. Ecol. 39:753-759.