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ABSTRACT

White-tailed deer (Odocoileus virginianus) use of soybean fields in Virginia was observed during the 1983 and 1984 growing seasons. Total deer observed and deer seen per observer-hour were both greater in 1983 (199 and 2.1, respectively) than in 1984 (122 and 1.8, respectively). The number of deer seen per observer-hour was related to crop phenology; it was highest during the early vegetative stages and decreased when the soybean plants entered reproductive growth stages. Most (90%) deer were sighted within 50 m of edge cover. In both years, the number of adult does seen was about 3 times the number of adult bucks. We propose that the findings on patterns of deer use of soybean fields be applied in simple population monitoring and in developing crop protection programs.

INTRODUCTION

While considerable information is available on the interactions among major North American agricultural crops and their principal insect pests, relatively little is known about the relationships between these crops and large vertebrate herbivores. Many studies, by necessity, have focused on immediate needs to assess local problems or develop a method to control herbivore damage to the crop (e.g., Strickland 1976, Allan et al. 1984). Problem-oriented research is often designed without a thorough understanding and/or application of the ecological relationships between the herbivore and the agroecosystem. Knowledge of the population structure of animals using agricultural areas can aid in understanding their ecological role in crop systems and in designing management plans for the crop and the animal.

The white-tailed deer (Odocoileus virginianus) is a good subject for studying large herbivore-crop interactions. It is generally abundant within its range, and there are numerous recorded incidents of overlap between deer habitat and agroecosystems. Most accounts of deer-agriculture associations are qualitative, describing the presence of deer in certain growing areas. For example, deer has been cited as a pest of soybeans (Glycine max L. Merrill; Flyger and Thoerig 1962, Moore and Folk 1978, Pile et al. 1981), causing damage by browsing on leaves and stems. While the association of deer with soybean fields is well established, quantitative data describing the sex and age of deer using soybean fields are lacking.

We studied deer use of soybean fields during the 1983 and 1984 growing seasons. Our objectives were to determine the sex and age class of deer using these fields, describe selected behavioral characteristics, and discuss applications to minimize crop yield loss.

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METHODS

The study area is in the Coastal Plain counties of Lancaster, Northumberland, and Richmond of Virginia's northern neck peninsula, which is bordered on 3 sides by the Potomac and Rapahannock Rivers and the Chesapeake Bay. Principal land uses are field crop production, primarily a corn-small grain-soybean rotation, and commercial forestry, mostly southern pines or mixed pine-hardwood. Marshy and wooded depressions serve as reservoirs for the deer population. Deer densities in the study area range from 8 to 14 deer/km^2 (Virginia Commission of Game and Inland Fisheries, Richmond, unpubl. data). There was a drought in 1983, with only 44% of the normal precipitation reported at the Warsaw station (Richmond County) during July and August (Virginia Crop Reporting Service 1984). The precipitation was normal for the same period in 1984 (Virginia Crop Reporting Service 1985).

We regularly monitored deer activity during 1983 and 1984 growing seasons (June - September) in 19 and 18 soybean fields, respectively. We visited each of these fields at least every 7 - 10 days. The fields were located on 4 farms representing areas of different estimated deer population densities and physical characteristics, such as amount of edge cover and field size, that might influence deer activity in the fields. Each year about half of the soybean fields were planted in conventionally tilled, wide rows planted by early June. Weeds in these fields were controlled by mechanical cultivation. The remaining fields were planted in double-cropped, no-till plantings in narrow rows following the harvest of a small grain, usually winter wheat or winter barley. No-till soybeans were planted as late as mid-July and weeds were controlled with herbicides. Field sizes ranged from 0.35 to 12.64 ha ($\bar{x}$ = 4.70 ha, SD = 3.32).

Observers remained in 1 location during the regular census periods, using a car as a blind. In addition, we did at least 1 weekly census while driving on roads adjacent to soybean fields, with one person driving while an observer visually scanned for browsing deer. Areas scanned included soybean fields and other open areas. In 1983 these open areas included land set aside for the payment in kind (PIK) program of the U. S. Department of Agriculture.

We made observations on 45 evenings in 1983 and 42 evenings in 1984. These observation periods began at least 1 h before sunset and continued until we could no longer distinguish deer. Experience in 1983 indicated that it became increasingly difficult to distinguish bucks from does after sunset. As our objective was to determine the sex of deer using the soybean fields, we shortened the post-sunset portion of the observation periods in 1984. We conducted 6 and 4 censuses at dawn in 1983 and 1984, respectively. We also collected data on any deer sighted during midday while we were collecting vegetation data in the fields. These midday sightings (n = 13) are included in analyses of sex and age class and distance from edge cover that deer were observed but not in the calculations of time spent in observation periods.

We recorded the following data for each deer sighted: field location, group size, sex and age class, initial time of sighting, phenological stage of the soybean plants (Fehr and Caviness 1977), height of the soybean plants (cm), and visual estimate of the distance from edge cover. This distance was determined by counting rows between the deer and edge cover (row width known), estimating the number of deer body lengths to edge cover, or comparing a deer's location to a landmark of known distance to edge cover. We define edge cover as woods, shrub lines, or tall (>1.5 m) corn. The distance from observer to deer was usually over 300 m, making it difficult to distinguish yearlings from older deer, especially near twilight. Therefore, all deer that were not fawns were classified as adults.

Sex of adults was determined by presence or absence of antlers. Those adults clearly lacking antlers were classified as does. If low light conditions precluded positive identification we classified the deer as an adult of unknown sex. We used binoculars to aid our identifications.

We calculated the total observer-hours conservatively. We included only time near dawn and dusk during which our principal task was to find deer. When two observers worked together, as in the driving census periods, the time spent was counted for only one observer. If >1 field was searched simultaneously during any type of observation period, the time was counted only once. We calculated the observer-hours per phenological stage differently, by crediting time for each field that was in view during the regular observation periods. For example, if an observer was watching for deer in 3 fields, 2 in a pre-flowering vegetative stage and 1 in a post-flowering reproductive stage for 2 hours, the phenological stage observer-hours would be vegetative = 4 and reproductive = 2.

We developed a sequential sample routine to estimate the number of observations needed to provide a reasonable estimate of the percent of adult bucks observed. We randomly ordered all observations of does and bucks for each year. We then calculated the percent of bucks based on cumulative addition of observations (i.e., 1 observation, 2, 3, ..., N). We did 5 runs of the randomly ordered observations for each year's data.

We used the Wilcoxon rank sum test for comparisons pertaining to time and distance (Conover 1980). We used χ^2 contingency table analysis (Sokal and Rohlf 1969) to compare distributions of distances we observed deer from edge cover. A standard error is reported with each mean.

RESULTS

Deer were usually feeding when initially sighted, and continued to feed unless disturbed by an observer walking toward the field to take measurements. The total number of deer sighted in 1983 (n = 199) was greater than 1984 (n = 122; Table 1), with most (91%) deer seen in the evening. The number of deer sighted per observer-hour for evening observation periods was significantly greater ($z = -2.23$, $p = 0.03$) in 1983 ($\bar{x} = 4.5 \pm 1.25$) than 1984 ($\bar{x} = 1.9 \pm 0.43$).

Sex and age class structure of deer observed in soybean fields varied significantly between years ($\chi^2 = 14.425$, $p = 0.003$), but this was due primarily to the higher number of fawns and unidentified adults sighted in 1983 (Table 1). The number of unidentified adults was greater in 1983 because the evening observation hours were extended well beyond sunset. The proportions of adults of known sex was similar between years ($\chi^2 = 0.342$, $p = 0.70$). The number of does observed in soybean fields was about 3 times the number of bucks observed each year.

Deer using soybean fields were generally observed alone or in small groups (Table 2). Fawns were usually with one or two does. Most (73%) bucks were in groups, usually with other bucks. Does were often sighted with other does or fawns, but 42% were alone. Mean group sizes were 2.9 ($\pm$ 0.11) and 2.3 ($\pm$ 0.20) in 1983 and 1984, respectively.

We examined the relationships between the time we initially sighted deer in the evening and time of sunset (Table 3). The average initial sighting time was 11 min later for all deer in 1983 than 1984 ($z = -3.164$, $p = 0.002$). There was a significant difference between years in initial sighting time for does ($z = -1.859$, $p = 0.063$) and bucks ($z = -2.97$, $p = 0.003$) but not for fawns ($z = 0.3078$, $p = 0.758$). The median

Table 1. Number of deer sighted by crop type in eastern Virginia, 1983 and 1984.

Year	Sex/ Age Class	Crop			
		Soybean, conventional	Soybean, no-till	Other[1]	Total
1983					
	Doe	22	47	18	87
	Buck	2	29	4	35
	Adult, Sex Unknown	13	28	4	45
	Fawn	2	26	4	32
	Total	39	130	30	199
1984					
	Adult Female	20	40	11	71
	Adult Male	6	15	1	22
	Adult, Sex Unknown	5	12	8	25
	Fawn	1	3	0	4
	Total	32	70	20	122

[1] winter wheat, winter barley, corn, and idle land

Table 2. Number of deer groups of different sizes observed in soybean fields in eastern Virginia, 1983 and 1984.

Year	Group size					
	1	2	3	4	5	7
1983	36	17	10	10	6	0
1984	49	16	1	1	0	2

initial sighting times for bucks and does were similar in both 1983 ($z = 1.524$, $p = 0.13$) and 1984 ($z = 1.601$, $p = 0.11$).

The distance deer in soybean fields were observed from edge cover was less in 1983 than 1984 ($z = 2.635$, $p = 0.008$; Table 4). However, the difference was not significant when the effect of fawns was not included ($z = 0.488$, $p = 0.626$). The difference between years was not significant ($z = 0.487$, $p = 0.629$) for adults of known sex. There were no significant differences between does and bucks in the median distance from edge cover in 1983 ($z = 0.814$, $p = 0.416$) or 1984 ($z = 1.174$, $p = 0.240$).

We pooled the data for both years to examine the frequency distribution of distance deer were sighted from edge cover (Fig. 1). Over one-half of all deer were observed less than 10 m from edge cover, and nearly 90% were sighted within 50 m from edge cover.

The observer-hours for soybeans in vegetative and reproductive phenological stages were 182 h and 42.5 h, respectively. The number of deer sighted during these stages was 116 and 15, respectively. These values were significantly different ($\chi^2 = 4.943$, $p = 0.035$) than would be expected if the number of deer sighted per growth stage was proportional to the number of observer-hours invested.

DISCUSSION

Limitations and biases of observation data must be discussed prior to interpretation. We made the assumptions that (1) evenings are the best time for counting deer and (2) bucks and does were equally observable during the study period. This first assumption is supported by detailed studies of deer daily activity patterns (Montgomery 1963, Michael 1970b, Krausman and Ables 1981) which identified dawn and dusk as times of maximum feeding activity during summer. Similarly, several studies (e.g., Downing et al. 1977, McCullough 1982) support the assumption that bucks and does in our study areas would be most nearly equally observable during the summer months. In addition, we found no significant differences between does and bucks in initial sighting time. Based on inferences from our study and literature pertaining to deer behavior, we assume that our data provide a reasonable estimate of the doe to buck ratio in the study area.

One must also consider how representative are data based on two field seasons with notably different weather, particularly in regards to temperature and precipitation. Comprehensive behavioral studies (Michael 1970b, Zagata and Haugen 1974) found inconsistent relationships between weather variables and deer activity. We found no year effect for most comparisons between 1983 and 1984, suggesting that weather did not bias the type of data collected.

The observation of more does than bucks is consistent with other studies of deer behavior (Michael 1970a, Krausman and Ables 1981, Sage et al. 1983). Some investigators (Flyger and Thoerig 1962; Virginia game wardens, pers. comm.) suggest that the closed season kill permits that are issued to control deer damage to crops are used primarily to take bucks and not to decrease the number of depredating individuals in the local population. Our observed doe to buck ratio is similar to the ratio of deer killed with the closed season permits to control reported deer damage in Virginia during 1983 and 1984 (Lyon and Scanlon, 1985). This suggests that, on average, bucks are not disproportionally culled with the crop damage permits. However, local hunting customs in the study area typically favor disproportionate culling of bucks with crop damage permits (game wardens, pers. comm.) Damage permits could be a more effective control tool if wardens exercised their option to specify that more does be killed.

Direct observation of deer use of soybean fields yielded only a small number of observations for a large amount of time invested. However, doe to buck ratios remained fairly constant during the growing season and between years. This suggests that weather effects are negligible and that several evenings of observation may yield a reasonable estimate of the sex and age class structure of deer using agricultural areas (Fig. 2). For example, the sample sizes (adults, known sex) needed to determine the percent of bucks ± 10% are 48 and 32 for 1983 and 1984, respectively.

This index to the composition of the local population might be considered by state game agencies when setting hunting seasons and limits. Data on doe to buck ratios can be used to modify hunting season quotas and seasons. In the case of Virginia, adjustments to increase the doe kill during the regular hunting season may alleviate the need to issue closed season permits and antlerless deer tags. Additionally, information on the sex ratio can be used to modify the antlerless and special crop damage permit system to more effectively decrease the size of the probable depredating deer population. For example, if few does are being taken in an area where does are frequently observed in agricultural fields, crop damage permits can be issued for does only.

Deer most frequently used the areas close to edge cover. Measurements of deer browsing on soybean plants, showed that over half of browsed plants occurred within 20 m of edge cover (Lyon, in prep.). Our findings are comparable to other studies of deer movement from cover. For example, Blymer and Mosby (1977) estimated that 65% and 90% of deer use of a clearcut occurs within 30m and 60m, respectively, of cover. However, we collected our data on a finer scale, allowing us to fairly well define the area of the field most susceptible to deer damage.

The distance that deer will move from edge cover can be used in crop management plans. For example, the most cost effective plan for using chemical repellents may be to restrict application to the area along edge cover. Alternatively, planting a low growing, low value buffer crop between edge cover and a high value crop may limit the yield loss the latter crop incurs. Information on the average distance from edge cover that deer will feed can also be useful in designing methods to sample for crop damage. For example, the sampling effort could be restricted to edge areas to maximize the amount of information collected for the time invested.

The relationship between deer use of soybean fields and soybean phenological development should also be considered in management plans for deer in soybean agricultural areas. Lyon (1984) found evidence through diet analysis of deer in the study area that deer browsing of soybeans occurs with decreasing frequency after soybean plants have flowered. This is consistent with our observations of more deer during vegetative than reproductive stages of soybean plant growth, as well as actual sampling of the soybean plants (Lyon, in prep.). Therefore, if control of the deer is warranted, efforts might be directed toward the early portion of the growing season. One also must consider the amount of the crop that the deer are eating (Lyon, in prep.) and the defoliation to yield loss relationships of soybean plants at the specific growth stage (Pedigo et al. 1981).

The methods and interpretations proposed in this paper should be applicable to evaluating the role of deer in other field crops. When considered in an interdisciplinary context, these efforts should contribute toward an integrated pest management approach to applied agricultural ecology.

LITERATURE CITED

Allan, G. G., D. I. Gustafson, R. A. Mikels, J. M. Miller, and S. Seogi. 1984. Reduction of deer browsing of Douglas-fir (Pseudotsuga menziesii) seedlings by quadrivalent selenium. For. Ecol. Manage. 7:163-181.

Blymyer, M. J. and H. S. Mosby. 1977. Deer utilization of clearcuts in southwestern Virginia. Southern J. Appl. For. 1: 10-13.

Conover, W. J. 1980. Practical nonparametric statistics. John Wiley and Sons, NY. 493pp.

Downing, R. L., E. D. Michael, and R. J. Poux, Jr. 1977. Accuracy of age and sex ratio counts of white-tailed deer. J. Wildl. Manage. 41: 709-714.

Fehr, W. R. and C. E. Caviness. 1977. Stages of soybean development. Spec. Rep. No. 80. Iowa State Univ. Coop. Ext. Serv. Ames, Iowa. 11pp.

Flyger, V. F. and T. Thoerig. 1962. Crop damage caused by Maryland deer. Proc. Annu. Conf. Southeastern Assoc. Game and Fish Commissioners. 16: 45-52.

Krausman, P. R. and E. D. Ables. 1981. Ecology of the Carmen Mountains white-tailed deer. U.S. Natl. Park Serv. Sci. Monogr. Ser. No. 15. 114p.

Lyon, L. A. 1984. Food selection by the white-tailed deer (Odocoileus virginianus) in the soybean agroecosystem. Bull. Ecol. Soc. Am. 65: 167. (Abstract).

Lyon, L. A. and P. F. Scanlon. 1985. Evaluating reports of deer damage to crops: implications for wildlife research and management programs. Proc. Eastern Wildl. Damage Control Conf. 2: 224-231.

McCullough, D. R. 1982. Evaluation of night spotlighting as a deer study technique. J. Wildl. Manage. 46: 963-973.

Michael, E. D. 1970a. Sex ratio and group composition in white-tailed deer. Proc. Annu. Conf. Southeastern Assoc. Game and Fish Commissioners. 24: 51-56.

Michael, E. D. 1970b. Activity patterns of white-tailed deer in south Texas. Texas J. Sci. 21: 417-428.

Montgomery, G. G. 1963. Nocturnal movements and activity rhythms of white-tailed deer. J. Wildl. Manage. 27: 422-427.

Moore, W. G. and R. H. Folk III. 1978. Crop damage by white-tailed deer in the southeast. South Carolina Wildl. and Marine Res. Dept. Columbia, SC. 14pp.

Pedigo, L., R. A. Higgins, R. B. Hammond, and E. J Bechinski. 1981. Soybean pest management. Pages 417-537 In D. Pimental, ed. Handbook of pest management in agriculture. Vol. 3. C. R. C. Press, Boca Raton, Fl.

Pile, C. M., M. A. Martin, and J. R. March. 1981. Foods of deer in southern Wisconsin. Wisconsin Dept. Natural Resources Res. Rep. 112. Madison, Wisconsin. 14pp.

Sage, R. W., Jr., W. C. Tierson, G. F. Mattfeld, D. L. Behrend. 1983. White-tailed deer visibility and behavior along forest roads. J. Wildl. Manage. 47: 940-953.

Sokal, R. R. and F. J. Rohlf. 1969. Biometry. W.H. Freeman and Company, San Francisco. 776pp.

Strickland, D. 1976. A literature review of deer damage and control measures. Wyoming Game and Fish Dept. Wildl. Tech. Rep. 4. Laramie, WY. 18pp.

Virginia Crop Reporting Service. 1984. Virginia Agricultural Statistics. Virginia Crop Reporting Service Bull. No. 48. 154 pp.

Virginia Crop Reporting Service. 1985. Virginia Agricultural Statistics. Virginia Crop Reporting Service Bull. No. 49.

Zagata, M. G. and A. O. Haugen. 1974. Influence of light and weather on observability of Iowa deer. J. Wildl. Manage. 38:220-228.

Table 3. Time after sunset that deer were first observed in soybean fields of eastern Virginia, 1983 and 1984.

Year	Sex/ Age class	Time after sunset (min)			
		N	X	SE	Range
1983	Doe	60	52	4.9	-38 to 128
	Buck	27	67	6.4	-24 to 145
	Adult, Sex Unknown	37	85	4.8	10 to 128
	Fawn	23	37	9.9	-38 to 112
1984	Doe	44	42	7.8	-76 to 260
	Buck	18	41	7.1	-45 to 75
	Adult, Sex Unknown	15	85	12.5	-47 to 255
	Fawn	4	49	4.1	-44 to 41

Table 4. Distance from edge cover that deer were observed in soybean fields of eastern Virginia, 1983 and 1984.

Year	Sex/ Age class	Distance (m)			
		N	X	SE	Range
1983	Doe	61	23	4.0	1-120
	Buck	24	25	6.8	1-120
	Adult, Sex Unknown	26	26	11.7	2-300
	Fawn	27	11	3.1	1- 60
1984	Doe	59	19	2.5	1- 85
	Buck	21	42	16.0	2-300
	Adult, Sex Unknown	17	32	4.6	1- 80
	Fawn	4	28	8.3	4- 40

Fig. 1. Distribution of deer (n = 238) observed in soybean fields in eastern Virginia grouped by distance (m) from edge cover.

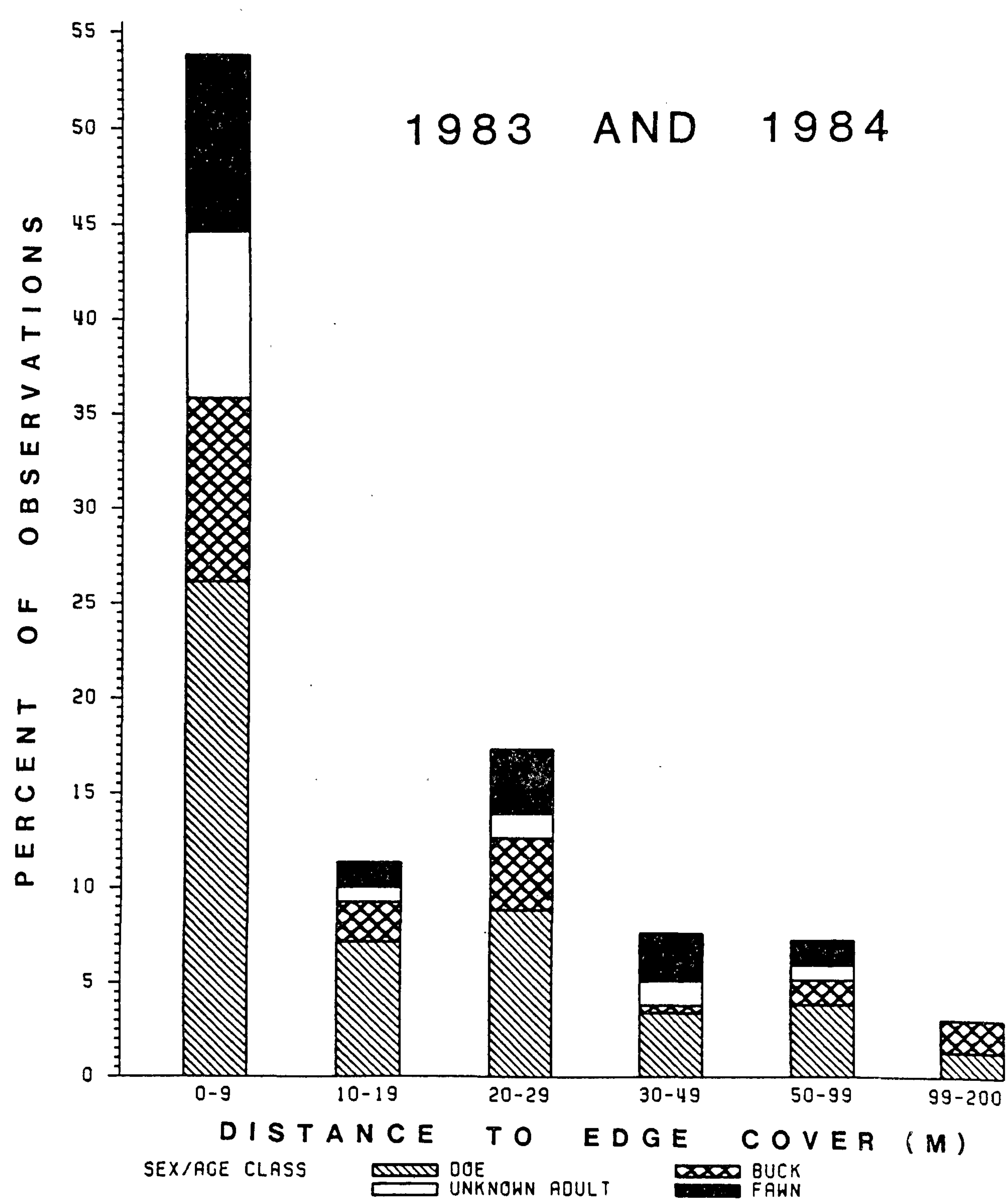

Fig. 2. Result of 5 runs of sequential sampling of sex of deer of known age observed in eastern Virginia, 1983 and 1984.