

OBSERVATIONS OF NORTH AMERICAN GOSHAWK INVASIONS

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R. F. GREEN, Department of Mathematical Sciences, University of  
Minnesota, Duluth, MN. 55812.

D. L. EVANS, 2928 Greysolon Road, Duluth, MN. 55812.

R. N. ROSENFELD, College of Natural Resources, University of  
Wisconsin, Stevens Point, WI. 54481.

H. J. EVANS, 2928 Greysolon Road, Duluth, MN. 55812.

## INTRODUCTION

Duluth, Minnesota, located at the western end of Lake Superior, is one of the best places in North America to observe the autumn hawk migration (Hofslund 1966, Heintzelman 1975). An annual hawk count was begun at Duluth in 1951. Originally, the count took place during two weekends in September, at the peak of the migration of Broad-winged Hawks (*Buteo platypterus*). Gradually the period of observation increased, extending later in the season. In 1972 a banding station was established near the main observation point and observations were extended to include virtually all of the hawk migration period. The numbers of hawks observed at Duluth during the autumn migration are quite impressive. Over a million hawks have been observed since the count began in 1951. Since 1972 the counts have ranged from 34000 to 75000, averaging 52000 per year. Of particular interest are Northern Goshawks (*Accipiter gentilis*), some of which are observed every year, but which show spectacular invasions at intervals of approximately ten years. The intensive observations which began in 1972 coincided with the beginning of a major invasion. Another large invasion occurred in 1982-3, with large numbers of Goshawks observed from 1981 to 1985. Since 1972 more than 21000 Goshawks have been observed at Duluth and nearly 5000 have been trapped and banded. This paper presents and discusses data on the age distribution and sex ratio of banded birds. The observations are compared with previous ones (Mueller, Berger and Allez 1977) made at Cedar Grove, Wisconsin, which are similar in some ways. Each trapped bird was weighed and banded, its crop checked, its wing and tail measured, and its age and sex determined. Age of birds was classified as: hatching year, second year, or after hatching year. Four birds, aged after hatching year, could not be sexed, and they are included in Table 1, but not Table 2. The ages of thirty other birds, whose sexes were determined, could not be determined more accurately than to say that they were after hatching year, and these birds are included in Table 1, and in Figure 3, but not in Table 2 or in Figure 2.

## RESULTS

### Age distribution

The age distribution of banded birds is shown in Table 2. If we assume that younger birds are no less likely than older birds to be banded, and that good reproductive success means about three hatchlings per breeding pair, then we would expect to observe at least as many hatching-year birds as breeding-age birds. If these assumptions are correct, then the data indicate substantial reproductive failure in 1972-3, 1982-3 and no better than half good reproductive success in 1974.

### Sex ratios

The proportion of males among banded birds is shown in Figure 3 for hatching-year and for after-hatching-year birds. The sex ratio of banded hatching-year birds was significantly male-biased every year except 1982, when the number of males and females was the same. During the non-invasion years of 1975-80 the male:female sex ratio of

hatching-year birds was between 3:1 and 4:1. The hatching-year birds still showed a male bias in all the invasion years except 1982. Second-year and after-second-year birds were grouped as after-hatching-year birds to treat the sex ratio since there was little difference between the sex ratios for the two classes. There are few after-hatching-year birds during non-invasion years, so Figure 3 includes only years with larger numbers of birds. A striking result is seen. The proportion of males among banded after-hatching-year birds decreased from year to year during each invasion. There were statistically significant decreases in the proportion of males from 1972 to 1973, from 1973 to 1974, from 1981 to 1982, and from 1982 to 1983. There were further decreases from 1974 to 1975 and from 1983 to 1984, but these were not statistically significant.

### WHAT CHARACTERIZES A GOSHAWK INVASION?

1. During an invasion many Goshawks are seen. If we wanted numbers to serve as a definition, however, there would be the question of how many birds constitute an invasion.
2. During an invasion the proportion of after-hatching-year birds is high. There is a high correlation between the number of Goshawks observed and the proportion of after-hatching-year birds among those banded (Spearman's rank correlation = 0.95). It may be that age distribution provides a better discriminant between invasion and non-invasion years than does number of birds observed, but we may be better off taking an agnostic position on the question of exactly what constitutes an invasion. Our observations give us the luxury of not having to struggle to decide whether a particular year showed an invasion or not. Quite clearly, there were invasions in 1972-3 and in 1982-3. The invasion of the 1970's probably extended to 1974. The years 1975 to 1980 were quite clearly non-invasion years, even though the number of migrant Goshawks observed ranged from about 100 to 300 per year. The years 1981, 1984 and 1985 are intermediate between invasion and non-invasion years and are better not regarded as either one.

### DISCUSSION: COMPARISON WITH EARLIER STUDIES

Our observations are similar to those of Mueller et al. (1977), but the larger number of Goshawks observed at Duluth reveal details not previously noticed. Mueller et al. (1977) observed the high proportion of older birds during invasions and the fact that the hatching-year birds observed during non-invasion years were predominantly male. For each age class Mueller et al. (1977) tried to compare the sex ratios during invasion years, with that during non-invasion years. However, they observed too few birds during non-invasion years to make the desired comparison directly, so they combined all the years 1950 to 1971 and compared the birds observed then to those observed during the 1972-3 invasion. They found a significantly lower proportion of males during the 1972-3 invasion than during other years for hatching-year and after-second-year birds. Our data show a significantly lower proportion of males among hatching-year birds during invasions, but we observe substantially higher sex ratios for these birds than do Mueller et al. (1977), both during

invasion and during non-invasion years. We did not observe enough after-hatching-year birds during non-invasion years to bear comparison with invasion years. However, the proportion of males among after-hatching-year birds decreased significantly from year to year during both invasions. There are several possible explanations for this pattern. One is that the smaller males, which are subordinate to the females, suffer differential mortality during invasions. Another possibility is that the winter prey species favored by the two sexes are slightly out of phase. Another possibility, and one that we favor, is that as the density of winter prey declines and food stress on wintering birds begins, the dominant older females displace the older males. As the prey decline becomes more severe the older females may emigrate, permitting some of the older males to stay and feed on the smaller prey which remain. It would be interesting to obtain more information about Goshawk prey populations and correlate it with migration data.

#### LITERATURE CITED

Heintzelman, D. S. 1975. *Autumn Hawk Flights, the Migrations in Eastern North America*. Rutgers University Press, New Brunswick, New Jersey.

Hofslund, P. B. 1966. Hawk migration over the western tip of Lake Superior. *Wilson Bulletin*, 78:79-87.

Mueller, H. C., D. D. Berger, and G. Allez. 1977. The periodic invasion of Goshawks. *Auk*, 94:652-663.

**Table 1. Number of Goshawks observed and number banded at Duluth, Minnesota, by year.**

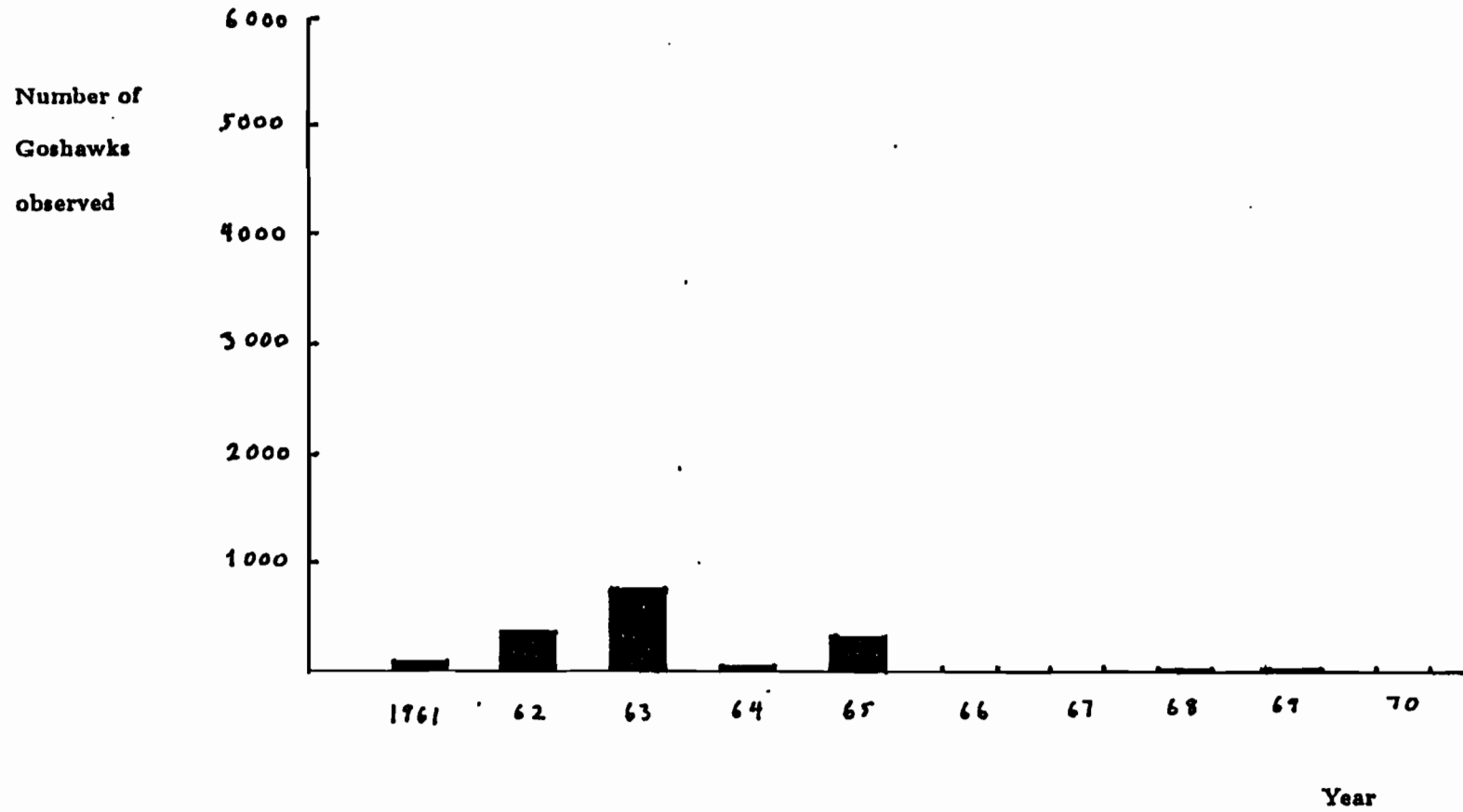
Year	Observation	Number of Goshawks	
	Days	Observed	Banded
1951	4	0	
1952	5	6	
1953	4	4	
1954	6	6	
1955	13	16	
1956	19	2	
1957	12	7	
1958	5	2	
1959	9	0	
1960	17	9	
1961	35	69	
1962	42	332	
1963	30	709	
1964	20	30	
1965	39	291	
1966	11	6	
1967	11	7	
1968	20	17	
1969	34	20	
1970	25	3	
1971	34	9	
1972	71	5382	391
1973	67	3566	652
1974	101	1400	410
1975	87	312	95
1976	91	308	91
1977	95	110	41
1978	92	166	51
1979	95	326	82
1980	95	250	85
1981	98	981	290
1982	114	5819	1439
1983	106	1605	636
1984	99	934	466

Table 2.

## Age and sex distribution of banded Goshawks.

Year	Hatching year		Second year		After second year		Total
	Male	Female	Male	Female	Male	Female	
1972	37	20	75	90	83	83	388
1973	27	14	15	22	212	334	624
1974	87	30	15	24	65	188	409
1975	57	18	0	4	2	14	95
1976	65	19	2	0	0	5	91
1977	29	8	4	0	0	0	41
1978	36	8	1	1	3	2	51
1979	51	15	7	5	2	2	82
1980	65	9	4	1	4	2	85
1981	147	28	70	16	25	4	290
1982	22	22	206	116	608	465	1439
1983	49	24	2	5	193	362	635
1984	217	68	3	6	55	116	465
1985	124	62	19	5	12	35	257

Figure 1. Number of Goshawks observed at Duluth, Minnesota, 1961 to 1985.



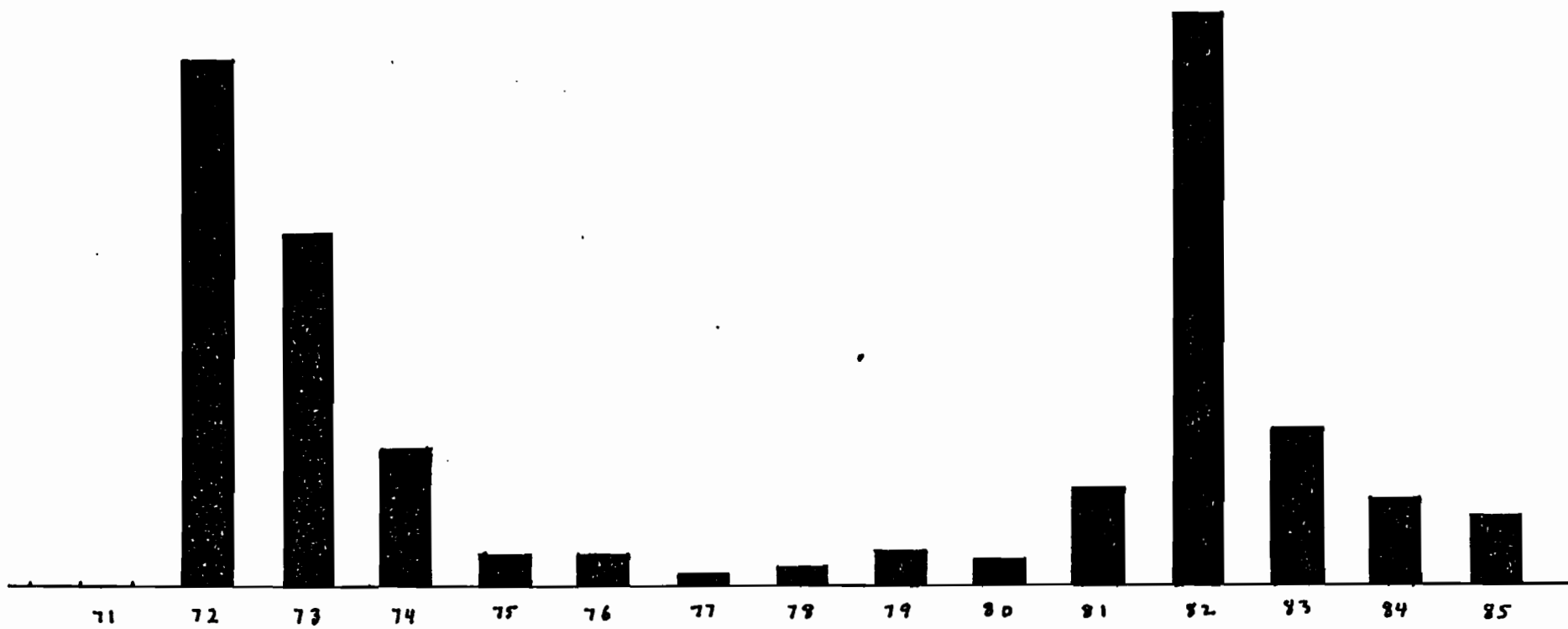


Figure 2. Age distribution of Goshawks banded, 1972 to 1985.

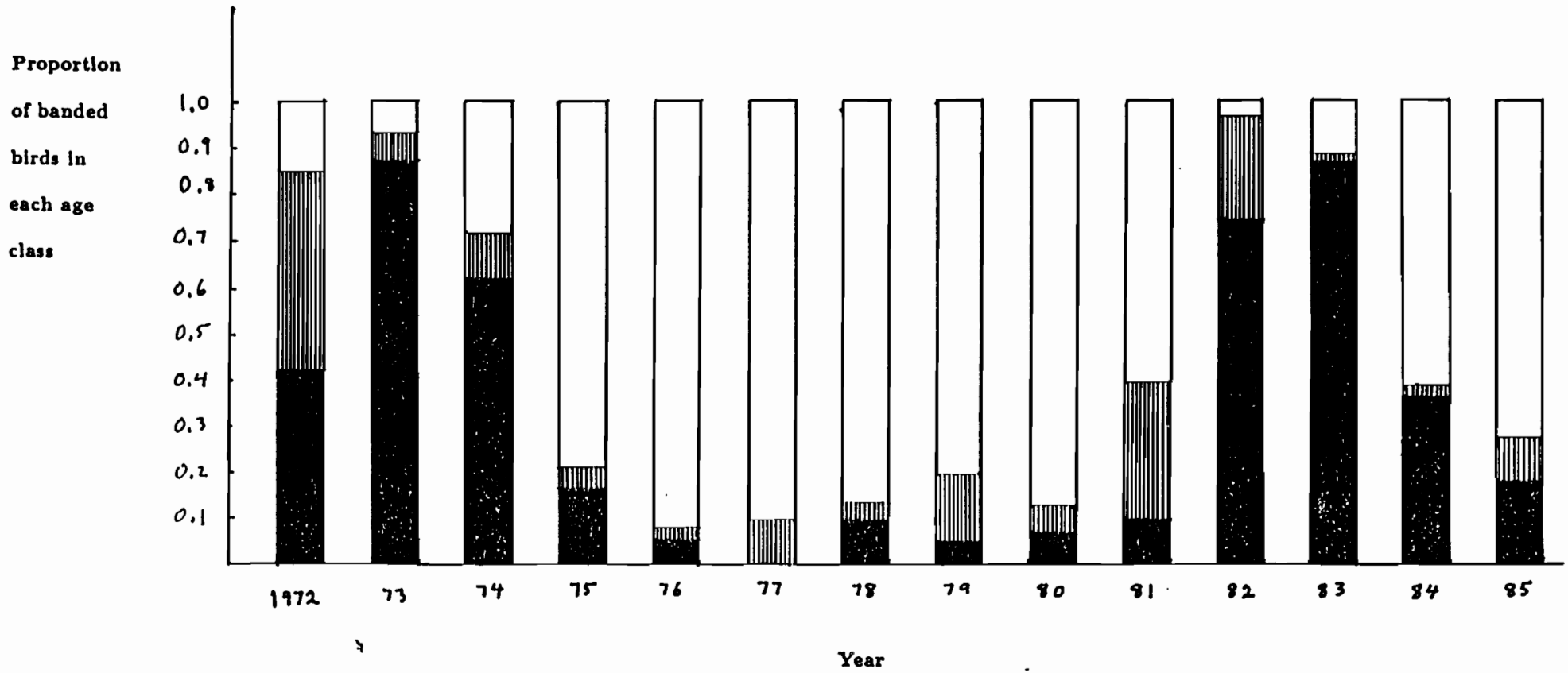


Figure 3. Proportion of males among Goshawks banded, for hatching-year and after-hatching-year birds, 1972 to 1985.

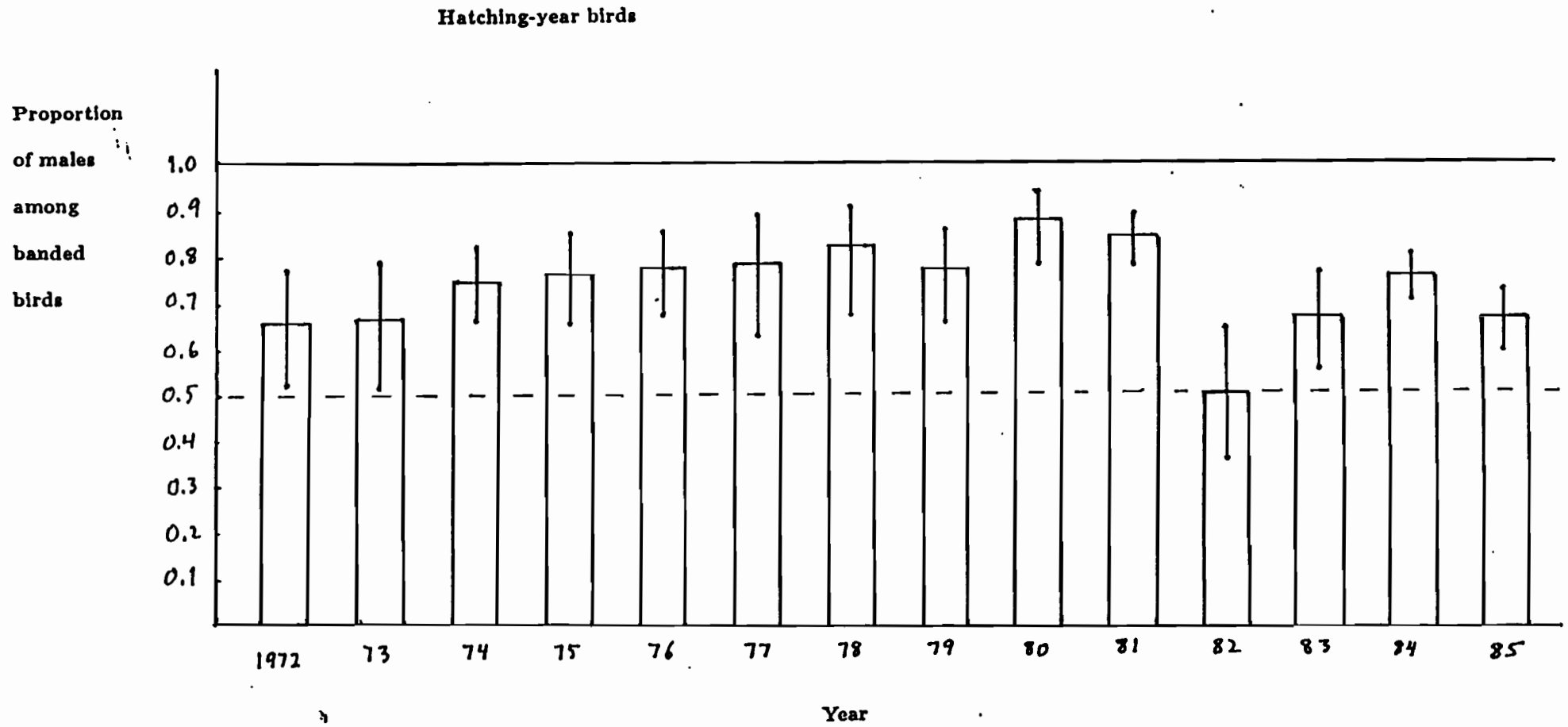


Figure 4. Relationship between the number of Goshawks observed and the proportion of older (after-hatching-year) birds among those banded.

