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TRAP TYPE CAN BIAS ESTIMATES OF SEX RATIO

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Abstract.—Sex ratio is a parameter of interest in many population studies. A key assumption of these studies is that the trapping method used does not bias the estimate of sex ratio in the sampled population. We use capture-recapture data of 2324 Serins (*Serinus serinus*) trapped in northeast Spain from 1985–1992 with Yunich platform traps and clap nets to test this assumption. Results show that in autumn the platform trap captured fewer females than expected by chance. This is probably due to dominant males monopolizing the small baited surface of the trap (trap: 0.36 vs. clap net: 3.24 m^2). The data additionally show a real increase in the proportion of males from autumn to winter, which may be related to differential mortality of the sexes.

EL TIPO DE TRAMPA PUEDE SESGAR LOS ESTIMADOS DE LA PROPORCIÓN DE SEXOS

Sinopsis.—La proporción de sexos es un parámetro de interés en muchos estudios de poblaciones. Una premisa clave de estos estudios es que el método de atrapar utilizado no sesge el estimado de la proporción de sexos de la población estudiada. En este trabajo utilizamos 2324 capturas de Verdecillo (*Serinus serinus*) atrapados en el noreste de España desde 1985 hasta 1992 con una trampa plataforma de Yunich y una red abatible, para poner a prueba la premisa. Los resultados muestran que, en otoño, la trampa plataforma captura menos hembras que las esperadas al azar. Esto se interpreta como una consecuencia de la dominancia de los machos sobre las hembras, lo que permite a estos monopolizar la pequeña superficie de alimentación de la trampa (trampa: 0.36 vs. red abatible: 3.24 m^2). Además los datos muestran un incremento real en la proporción de machos de otoño a invierno, lo cual podría estar relacionado con una mortalidad diferencial entre los dos sexos.

Capture-recapture methods are commonly used to estimate population sex ratios (e.g., Lago 1979, Shreeve 1980). A critical assumption for this method is that captured individuals are an unbiased sample of the target population. However, there is increasing evidence that this is not always the case, and that different trapping methods can produce sex biases in the sampling of the population (Balph and Balph 1976, Borras and Senar 1986).

Dominance has been suggested to be one of the ultimate causes of these biases because dominant males use their higher social rank to monopolize traps with a small surface, and are overrepresented in these traps (Balph and Balph 1976). According to this, we could hypothesize that clap nets, which usually have a large baited surface, should obtain less-biased samples than traps with small baited surface, as drop-door, shelf, or string traps (Davis 1981, McClure 1984).

The aim of this paper is to test this hypothesis in the Serin (*Serinus serinus*). Because complex patterns of interactions between sexes, trapping method, and other variables (e.g., age, season or residence status) can appear (Borras and Senar 1986, Senar 1988, Senar et al. 1994), we use a multifactorial approach simultaneously using all of these variables. Results suggest that traps can bias samples in favor of males, but that this bias is only important in autumn.

METHODS

Trapping of Serins was carried out from 1985–1992 at a suburban area in Barcelona, northeastern Spain (41°25′N, 02°10′E). Birds were trapped during autumn (1 October–21 December) and winter (22 December–31 March). A total of 2324 captures was used in the analysis, 927 of them being Serins previously unbanded.

We compared the Yunich platform trap (Yunick 1971a,b,c), and the clap net (Bateman 1979). The platform trap is an elevated wire funnel like a cage, with two doors, one at each end. These doors are manually operated by a pull string. The clap net is a small hand operated version of the cannon net, and functions with two nets that swing over the birds simultaneously when a line is pulled by the operator (McClure 1984). Both traps were associated with baited feeders and were used simultaneously at the same locality (distance between the two trapping devices was 60 m). The baited area in the trap measured 60 × 60 cm, and in the clap net 180 × 180 cm. Both methods were operated throughout the day. Because no differences in sex ratio between morning (before 1200 h) and afternoon (after 1200 h) trappings were found (χ^2 = 0.007, P = 0.80), data from both periods were pooled. Additional samples of birds were obtained using mist nets (n = 213 birds), which were used to improve the estimation of the sex ratio in the population.

All birds were individually banded on first capture. Age and sex were determined according to Svensson (1992). Two age classes were defined: yearlings (hatching year [HY] and second year [SY]; Euring ages 3 and 5), and adults (after hatching year [AHY] and after second year [ASY]; Euring ages 4 and 6).

We included residence status (new banded birds vs. recaptured ones) in the analyses, in addition to season, age, and sex (Senar 1988). We used residence status in a broad sense to classify birds into those that do not have yet any experience with trapping devices (new banded birds) from those already familiar with them (recaptured ones).

The five-factor contingency table relating the number of birds trapped with each method and factors sex, age, residence status, and season was analysed using backward stepwise log-linear analysis with an automatic model selection procedure, which allowed us to obtain the simplest model that fit the data with the least number of interactions necessary (Norusis 1986).

RESULTS

The best model explaining the variation in the five-factor log-linear analysis included five interactions (goodness-of-fit test: χ^2_{14} = 15.11, P = 0.371). The first one related trapping method to sex and season, showing that in autumn, the trap captured a smaller proportion of females than the clap net. This trend was not significant in winter (Tables 1 and 2).

TABLE 1. Results of the log-linear test between the variables capture method (clap-net vs. platform trap), sex, age (yearlings vs. adults), residence status (newly banded bird vs. recaptured ones) and season (autumn vs. winter). Only interactions between capture method and the other variables are displayed.

	Partial Association		Marginal Association	
Hypothesis	χ^2	*P*	χ^2	*P*
Capture method × Sex	9.38	0.002	1.39	0.24
Capture method × Age	0.57	0.45	6.80	0.009
Capture method × Residence	481.44	<0.001	390.33	<0.001
Capture method × Season	165.38	<0.001	91.96	<0.001
Capture method × Residence × Sex	0.11	0.74	0.02	0.87
Capture method × Residence × Age	0.28	0.60	0.03	0.87
Capture method × Residence × Season	15.37	<0.001	13.59	<0.001
Capture method × Sex × Season	11.26	0.001	6.87	0.009
Capture method × Sex × Age	2.35	0.13	4.00	0.045
Capture method × Age × Season	1.77	0.18	1.32	0.25
Capture method × Residence × Sex × Age	0.24	0.62	0.23	0.63
Capture method × Residence × Sex × Season	0.03	0.86	0.07	0.79
Capture method × Residence × Age × Season	4.60	0.032	5.85	0.02
Capture method × Sex × Age × Season	0.42	0.52	0.05	0.82
Capture method × Sex × Age × Residence × Season			0.32	0.57

To discern which of the two trapping methods (or both) were biasing the samples of the population (e.g., the trap may capture a low proportion of females either because females are trapped in low number in this trap, or because females readily enter into the clap net), we estimated the real proportion of females in the population, in both periods. This was done by computing the number of *individuals* of either sex captured, irrespective of the method (clap net, trap, and mist nets). Hence, each individual was included only once (autumn, $n = 894$; winter, $n = 858$ birds). A comparison of the estimated proportion of females in the population with that from the two analyzed trapping methods showed that in autumn, the trap captured a smaller proportion of females than available in the population, but not in winter (autumn: $\chi^2 = 12.37$, $P < 0.001$;

TABLE 2. Contingency tables relating sex and residence status with capture method by season (autumn vs. winter). Expected frequencies within parentheses.

	Autumn		Winter	
	clap net	platform trap	clap net	platform trap
Females	345 (312)	161 (194)	236 (239)	418 (415)
Males	331 (364)	260 (227)	355 (352)	608 (611)
Unbanded	491 (365)	102 (228)	299 (185)	207 (321)
Recaptures	185 (311)	319 (193)	292 (406)	819 (705)

TABLE 3. Estimated proportion of birds by age and sex class in the population (every captured bird is only counted once by season). Percentages within parentheses.

	Yearlings		Adults	
	autumn	winter	autumn	winter
Females	377 (49.7)	284 (43.6)	59 (44.0)	69 (33.4)
Males	381 (50.3)	367 (56.4)	75 (56.0)	138 (66.7)

winter: $\chi^2 = 0.016$, $P = 0.90$). On the contrary the clap net did not show any significant trend (autumn: $\chi^2 = 0.70$, $P = 0.40$; winter: $\chi^2 = 0.16$, $P = 0.68$). This suggests that the clap net is not biasing the trapping sample, but the trap is capturing a lower proportion of females.

The second interaction showed that the clap net captured a higher proportion of unbanded birds than the trap, especially in autumn (Tables 1 and 2). The third interaction related trapping method to age, so that the trap captured a higher proportion of adult birds than the clap net (Table 1).

The fourth interaction showed that a higher proportion of resident birds were males ($\chi^2 = 20.14$, $P < 0.0001$). The last interaction related season, sex, and age, so that there was an increase in the proportion of trapped males from autumn to winter (54% vs. 60%), but this increase was more important for the adult class (Tables 1 and 3). The detected increase in the percentage in males could be either because of a real increase in the number of males in the population or a decrease in the number of females. We therefore estimated, as before (see first interaction), the number of males and females in the population, within each age class (Table 3). In the yearling class, the reduction in the proportion of females from autumn to winter was because of a reduction in the number of females ($\chi^2 = 5.25$, $P = 0.022$), meanwhile in the adult class this reduction was because of an increase in the number of males ($\chi^2 = 3.97$, $P = 0.046$) (Table 3).

DISCUSSION

Our results support the hypothesis that females may be trapped in smaller percentages than males when using baited trapping devices with small surfaces. This may be due to the higher dominance status of males and their associated ability to monopolize smaller baited surfaces (Balph and Balph 1976).

Interestingly, this bias was only significant in autumn. During this season natural food resources are readily available (Glue 1982), so that females could shift to alternative habitats/areas to avoid male competition (e.g., Ekman and Hake 1988, Fretwell 1969, Hake and Ekman 1988). However, in winter, females may be more ready to incur the risk of aggression because of a general reduction in resources available. Alternatively, male aggression may be reduced in winter due to the general reduction in temperature, increasing feeding time in males (Pulliam and

Caraco 1984), which in turn would allow females to increase the use of the baited traps.

Data show that unbanded birds (probably migrants or transient birds) are more often captured with the clap net. This has been shown previously (Senar 1988) and has been related to the shyness for trap structures by newly arrived birds. Alternatively, dominance by residents over transients, through a prior-residence effect, could also explain this result in a way similar to the monopolization of the trap by males. This effect is stronger during autumn, probably because of a higher abundance of migrant birds in this period (Asensio 1985), although the same reasoning presented to explain the seasonal variation in sex bias could again be used here.

Adults tend to be trapped more often at the trap than at the clap net. This could be explained by adults being dominant to young birds, but also could be related to the greater experience of adults (Enoksson 1988, Hogstad 1989), which may perceive the lower predation risk of feeding at the trap because of its elevated position (see Yunick 1971b).

Results show an increase in the proportion of male from autumn to winter. This is probably related to a true change in the population sex ratio, due to a greater female mortality across the winter (Breitwisch 1989, Shreeve 1980, pers. obs.). Results suggest that this could be more important for adult than for yearling birds. However, detailed inspection of the estimated population composition at the two periods suggests that, although yearling females seem to incur a reduction in numbers, the reduction in the proportion of females in the adult class is because of an increase in the number of adult males in winter. Data suggest that during December and January there is a new arrival of migrants, perhaps adult birds, in addition to the typical early autumn movements (Senar 1986), which could explain the shift in the sex ratio of the adult class.

Altogether, these data show that care must be taken when analyzing sex ratios from large capture-recapture datasets, because sex ratio can vary according to trapping method and season. The data also show that clap nets or large traps are more advisable than typical traps to study sex ratios.

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