A Study of a Population of *Passer domesticus* that has been Shown to be Carrying St. Louis Encephalitis

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Abstract

A mark-recapture program was conducted at a stockyard on the northeast side of Seymour, Indiana. Blood samples taken from *Passer domesticus* at this site had indicated the presence of active St. Louis encephalitis virus. In 28 samples collected between June 30, 1977 and March 19, 1978, 1,068 *P. domesticus* were collected. Population parameters were estimated from the data applying a variation of Jolly's stochastic model. The very high population estimates and high proportion of juveniles in the population suggested that flocks of juveniles foraging in adjacent crop fields were being attracted to this urban site. The resulting high population density of this species may have played a significant role in the transmission cycle of St. Louis encephalitis at this site.

Introduction

In the summer of 1977, following a statewide epidemic of St. Louis encephalitis (SLE) in the summer of 1975 and a smaller outbreak in 1976, the Indiana State Board of Health initiated an arbovirus surveillance program. Blood samples were taken from *Passer domesticus*, the House Sparrow, in twenty counties across the state in order to identify viral activity. Sampling sites were selected on the basis of availability of large numbers of birds, the presence of suitable mosquito breeding habitat, and proximity to confirmed cases of SLE. Since SLE in the midwest is primarily an urban phenomenon, many of the sampling sites were located in urban areas. In light of what was understood about the ecology of *P. domesticus*, the use of urban sampling sites raised several objections. A description of the seasonal population ecology of this species is given by Summers-Smith (7). Man-made structures provide ideal nesting opportunities for this species and colonial nesting is common. Consequently, adult breeding populations of *P. domesticus* are centered in towns and cities. In late spring the first juveniles fledge and leave the nest. These juveniles do not remain in the towns and cities with their parents, instead they move into the surrounding crop fields to forage nomadically. These juveniles exhibit a strong flocking instinct and by midsummer large flocks containing several thousand birds may develop. As breeding ceases in the fall, the adults joint the immatures in the rural areas, but even during this time the adults remain strongly attached to the nesting site, visiting it frequently. As winter sets in, all surviving individuals return to the towns and cities to overwinter. This species is known to be extremely sedentary and even the foraging juveniles usually never wander more than a few miles from their birthplace. The adults breeding in the urban areas are even more sedentary and probably never wander more than a few thousand yards from their nests. Since urban populations are made up primarily of breeding adults with extremely restricted ranges, it was suggested that urban sampling sites were a poor choice since they only yielded information about the viral activity in a very small area. It was further suggested that this method did not yield any better coverage than a program employing sentinal flocks. Sentinal flocks are caged birds that are periodically checked for viral activity. Due to the number of man hours required to capture wild birds, sentinal flock programs are much less expensive to operate. In order to address these criticisms, an independent mark-recapture program was planned to look at the population dynamics of *P. domesticus* at one of these urban sites. The first serologic evidence of the presence of active SLE virus was obtained from a small stockyard on the northeastern edge of Seymour, Indiana. This was chosen as the study site.

Study Area and Methods

The study site was the Seymour Stockyard on the northeastern limit of Seymour, Indiana. The feed provided for the livestock served as the primary attractant for *P. domesticus.* The livestock shelters also provided a limited number of nesting sites. A bank of trees on the south side of the stockyard served as a communal roost and several residential homes in the immediate vicinity provided additional nesting sites. On the north and east, adjacent to the stockyard, were extensive crop fields planted primarily in corn *(Zea mays).* On the east side of the main shelter was a catch basin. In an attempt to identify mosquito breeding sites, Jackson County health officials obtained several samples of *Culex pipiens*, the presumed vector of SLE, from this empoundment.

Epidemiologic evidence also implicated this general vicinity as an area of potential viral activity. Of the 17 confirmed cases of St. Louis encephalitis in Jackson County since 1975, two of the victims lived within 1/4 mile of the stockyard and another 14 of the victims lived within one mile of it.

Between June 30, 1977 and March 19, 1978, 1,068 House Sparrows (*P. domesticus*) were captured. These included 335 birds captured by the State Board of Health. From these 291 blood samples were taken and 11 were found to be positive for SLE. Birds were captured in Japanese mist nets, 12 meters long and 2.6 meters high with a mesh size of 36 millimeters. These nets were placed so as to maximize the number of birds captured. Individual birds were banded with aluminum bands, size 1B, placed around the right tarsus. The age, sex, and time of capture of each individual was recorded.

Individuals were aged and sexed after a technique described by Johnston (3). However, immature birds which had not entered their post-juvenile molt were not sexed. Due to a persistence of the yellow coloration at the base of the mandibles, it was often possible to identify an individual as a first year bird even after it had acquired its adult plumage following the post-juvenile molt.

Population parameters were then estimated from the data using a modification of Jolly's stochastic model developed by Seber (6). A simple computer program was employed to speed calculations.

Results

Data

The data from 28 samples is summarized in Table I. Of the 1,068 birds captured, 1,005 were subsequently banded and released. There were two situations where captured birds were not banded. First, data collected by the Indiana State Board of Health arbovirus surveillance team is also included here. Blood samples were taken from these birds and a bird occasionally died as a result. The State Board of Health team also selectively bled juveniles and time requirements did not allow banding or sexing of adults. These birds are listed in Table I as sex unknown. In order to make their data useful to this study, the State Board of Health team did record the total number of captures.

Of the 1,005 birds banded, 144 were subsequently recaptured. This produced an overall recapture rate of 14.3%.

TABLE I *Banding Data for Seymour Stockyard*

Date	Captures				Recaptures				Total
	Males	Females	Juveniles	Unknowns	Males	Females	Juveniles	Unknowns	
* 6/30/77	6	8	7	0	0	0	0	0	21
7/9/77	6	3	24	0	0	0	0	0	33
* 7/14/77	0	0	34	0	0	1	0	0	35
7/17/77	8	5	32	0	0	0	1	0	46
** 7/21/77	1	4	14	6	2	0	2	0	29
7/24/77	7	5	76	1	0	0	8	0	97
** 7/28/77	0	0	20	14	0	0	3	0	37
** 8/4/77	0	0	22	14	0	0	3	0	39
* 8/11/77	4	1	12	0	1	0	3	0	21
8/13/77	1	0	74	0	0	0	2	0	77
* 8/18/77	0	0	18	0	0	1	1	0	20
** 8/25/77	0	0	18	10	0	0	3	0	31
8/27/77	0	0	68	1	0	0	12	0	81
9/10/77	1	2	122	1	0	0	15	0	141
* 9/15/77	0	0	18	0	0	0	3	0	21
* 9/21/77	0	0	8	0	0	0	3	0	11
* 9/28/77	0	0	19	0	0	0	6	0	25
10/2/77	3	0	40	1	1	0	5	0	50
10/16/77	3	1	15	0	0	0	8	0	27
*10/21/77	2	0	17	0	0	0	6	0	25
11/6/77	5	0	17	0	0	0	6	0	28
*11/16/77	3	0	6	0	0	0	5	0	14
11/19/77	17	1	57	0	2	0	20	1	98
1/6/78	2	0	7	0	2	0	5	0	16
1/22/78	4	0	11	0	2	0	3	0	20
2/26/78	1	1	2	0	1	0	1	0	6
* 2/28/78	2	2	0	0	2	0	0	0	6
3/19/78	5	3	1	0	1	1	2	0	13
Totals	81	36	759	48	14	3	126	1	1,068

* Collected by State Board of Health

** Samples selective for juveniles

Estimates of Population Parameters

A modification of Jolly's stochastic model for estimation of population parameters was applied to the data (6). The notation used in this discussion is consistent with Jolly's original notation (4), however, other authors referred to here have adopted their own notation. An excellent guide to equivalent notation is given by Cormack (2).

The Jolly method offers considerable advantages over previous models. This model may be applied to an open population, one in which there may be death, emigration, recruitment, or immigration. Any number of samples may be taken with varying intervals between samples. It is also not necessary to return all organisms to the population, thereby allowing for accidental death due to trapping or marking. Finally, it may be applied in the special case where entire samples are permanently removed from the population, as in commercial exploitation.

Before this model may be applied legitimately, the data must meet certain criteria. These requirements are:

1. The marked individuals become randomly mingled with the remainder of the population
2. Marked individuals are not affected by that marking
3. The two samples are both taken randomly or all individuals are equally available for capture with respect to mark status
4. The period of time taken during sampling must be small relative to the time interval between samples
5. Being captured does not affect the probability of an individual being subsequently captured.

The aluminum leg bands used in this study are those provided by the Fish and Wildlife Service. This is the preferred method since it is believed to have little or no effect on the survival of the bird.

Beimborn (1) showed that mist nets were not selective on the basis of sex and no evidence exists to suggest that they are selective on the basis of age. However, visual observations of the on site populations supported the estimated adult to immature ratios.

Finally, it was necessary to determine if the data from birds bled by the State Board of Health could be legitimately included in this study. If the bleeding reduced their survival probability significantly from that of the rest of the population, it would lead to an inflated estimate of population size. In light of the fact that a bird occasionally died from induced shock, it was necessary to study the problem more closely. In at attempt to determine any long term differences in survival between bled and unbled birds, the ratios of banded to recaptured birds were compared: 282 birds were bled, banded, and released; of these 53 were recaptured and 723 birds were simply banded; of these 91 were recaptured. This leads to a recapture rate of 18.8% and 12.6% respectively. This difference was not significant ($p > .01$).

In light of these considerations it is believed that this method may be legitimately applied. There is another consideration in applying Jolly's original model: several of the samples contained a small number of recaptures. Fortunately, Seber (6) has developed a modification of Jolly's original method designed for small numbers of recaptures. It was this modified model that was used to estimate the population parameters in this study. Seber warns that even with the modified estimate, where recaptures are less than ten, the estimate may not even suggest the order of magnitude of the actual parameter and on this basis he suggests that samples where the number of recaptures is less than ten be deleted. However, since the degree of error is not only a function of the number of recaptures, but also a function of sample size, and since there is a reliable estimate of standard error, calculations for all samples have been made. However, certain estimates may be deleted from discussion on the basis of an unacceptably large standard error. There were also cases where variables placed in the variance formulae were evaluated as zero. Where this resulted in division by zero it was impossible to make an estimate of error. No estimate is shown in Table IV in these cases.

Trellis diagrams constructed after the method described by Jolly (4) are presented in Table II and Table III. The estimated population parameters and their standard errors are presented in Table IV. The parameters estimated after the method of Seber (6) are:

$\hat{N}_i$ = estimated number in the population when the ith sample is taken

$\hat{\phi}_i$ = estimated probability that an individual alive at the moment of release of the ith sample will survive until the time of capture of the (i+1)th sample, including emigration and death

$\hat{B}_i$ = estimated number of new animals joining the population in the interval between the ith and the (i+1)th samples and alive at time i+1.

Variance estimates for $\hat{\phi}_i$ and $\hat{B}_i$ were calculated after the method of Jolly (4) and the standard errors of the estimates were obtained by taking the square roots of these variances.

Seber (6) points out that Jolly's formula for the variance of $\hat{N}_i$,

$$\mathrm{Var}(\hat{N}_i)=N_i(N_i-n_i)\left[\left(\frac{M_i-m_i+s_i}{M_i}\right)\left(\frac{1}{R_i}-\frac{1}{S_i}\right)+\frac{1-\alpha_i}{m_i}\right]+N_i-\sum_{j=O}^{i-1}\frac{N^2i(j)}{B_j},$$

may be broken into two parts:

$$\text{A.}\quad N_i(N_i-n_i)\left[\left(\frac{M_i-m_i+s_i}{M_i}\right)\left(\frac{1}{R_i}-\frac{1}{S_i}\right)+\frac{1-\alpha_i}{m_i}\right]$$

which estimates the variance due to errors of parameter estimation, and

$$\text{B.}\quad N_i-\sum_{j=O}^{i-1}\frac{N^2i(j)}{B_j}$$

which estimates variance due to stochastic fluctuation of the parameter.

Seber shows that the second element is negligible unless the proportion of the population banded is large. Since that is not the case here, the tedious

TABLE II *Trellis Diagram for Estimation of* Z_i

Sample Number	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
	0																										
	0																										
	1	1																									
	0	0	1																								
	1	2	2	4																							
	0	1	2	5	8																						
	0	0	0	0	0	3																					
	0	0	0	0	0	3	3																				
	0	0	1	2	2	3	4	4																			
	0	0	0	0	0	0	0	0	2																		
	0	0	0	0	0	0	0	0	2	2																	
	0	0	0	0	0	2	2	2	3	3	3																
	0	0	0	2	4	5	5	7	10	11	11	12															
	0	0	1	3	6	7	7	8	9	9	11	12	15														
	0	0	0	0	0	0	0	0	0	1	1	1	2	3 = m_i													
	0	1	1	1	1	2	2	2	3	3	3	3	3	3	3												
	0	0	0	0	0	1	1	2	2	2	2	2	5	6	6	6											
	0	1	1	2	2	2	2	2	2	2	2	2	4	4	6	6	6										
	0	0	0	0	1	1	1	1	1	2	2	4	4	8	8	8	8	8									
	0	1	1	1	1	2	2	2	2	2	2	2	2	4	4	5	5	5	6								
	0	0	0	0	0	1	1	1	1	2	2	2	2	4	5	5	5	6	6	6							
	0	0	0	0	0	1	1	1	1	1	1	1	2	3	3	3	4	5	5	5	5						
	0	1	1	4	4	5	6	6	6	8	9	10	13	18	19	19	19	19	20	22	22	23					
	0	0	0	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	5	5	6	7	7				
	0	0	0	1	1	1	1	1	1	2	2	2	2	3	4	5	5	5	5	5	5	5	5	5			
	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	2	2	2	2	2	2	2	2		
	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	2	2	2	2	2	2	2	2	2	2	2	
	0	0	0	0	0	0	0	0	0	1	1	1	2	3	3	3	3	3	3	3	3	3	3	3	3	3	4
Z_i=	2	7	10	24	25	39	38	38	46	52	52	45	49	61	64	60	55	51	48	44	45	19	12	7	5	3	0

where:

Z_i = marked individuals before time i which are not caught in the ith sample but are caught subsequently

m_i = number of marked individuals in the ith sample

TABLE III *Trellis Diagram for Estimation of R_i*

Date	n_i	s_i	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	
6/30	21	20																												
7/9	33	33	0																											
7/14	35	32	1	0																										
7/17	46	46	0	0	1																									
7/21	29	23	1	1	0	2																								
7/24	97	94	0	1	1	3	3																							
7/28	37	23	0	0	0	0	0	3																						
8/4	39	23	0	0	0	0	0	3	0																					
8/11	21	18	0	0	1	1	0	1	1	0																				
8/13	77	76	0	0	0	0	0	0	0	0	2																			
8/18	20	20	0	0	0	0	0	0	0	0	2	0																		
8/25	31	21	0	0	0	0	0	2	0	0	1	0	0																	
8/27	81	79	0	0	0	2	2	1	0	2	3	1	0	1																
9/10	141	137	0	0	1	2	3	1	0	1	1	0	2	1	3															
9/15	21	21	0	0	0	0	0	0	0	0	0	1	0	0	1	1														
9/21	11	11	0	1	0	0	0	1	0	0	1	0	0	0	0	0	0													
9/28	25	25	0	0	0	0	0	1	0	1	0	0	0	0	3	1	0	0												
10/2	50	50	0	1	0	1	0	0	0	0	0	0	0	0	2	0	2	0	0											
10/16	27	27	0	0	0	0	1	0	0	0	0	1	0	2	4	0	0	0	0	0										
10/21	25	25	0	1	0	0	0	1	0	0	0	0	0	0	0	2	0	1	0	0	1									
11/6	28	28	0	0	0	0	0	1	0	0	0	1	0	0	0	2	1	0	0	1	0	0								
11/6	14	14	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	1	1	0	0	0							
11/19	98	98	0	1	0	3	0	1	1	0	0	2	1	1	3	5	1	0	0	0	1	2	0	1						
1/6	16	16	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	0					
1/22	20	20	0	0	0	1	0	0	0	0	0	1	0	0	0	1	1	1	0	0	0	0	0	0	0	0				
2/26	6	6	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0			
2/28	6	6	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0		
3/19	13	13	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	
Total	1068	1005	2	6	4	18	9	17	2	4	10	8	3	5	19	15	6	2	1	4	3	2	1	2	0	0	0	0	1	= R_i

where:

n_i = number of individuals in the ith sample

s_i = number of individuals released from the ith sample after marking

R_i = number of s_i individuals released from the ith sample that are caught subsequently

TABLE IV *Estimated Population Parameters*

Date	$\hat{N}_i$	Standard Error of $\hat{N}_i$	$\hat{\phi}_i$	Standard Error of $\hat{\phi}_i$	$\hat{B}_i$	Standard Error of $\hat{B}_i$
6/30			.486	.393	338.5	262.3
7/9	330.3	242.8	1.082	.684	1,335.7	812.7
7/14	1,663.2	1,001.3	.329	.163	64.9	581.9
7/17	604.8	601.7	.871	.271	-135.0	529.1
7/21	369.6	195.6	1.736	.592	923.5	626.2
7/24	1,523.8	646.9	1.394	.993	986.3	1,912.3
7/28	2,992.5	2,646.3	.553	.447	216.3	1,371.2
8/4	1,854.0	1,343.6	.339	.167	-312.9	380.7
8/11	306.4	149.6	1.729	1.877	8,924.6	7,875.5
8/13	10,284.4	8,066.0	.586	.368	-4,061.1	4,919.4
8/18	1,925.0	1,660.5	.661	.434	287.2	1,202.2
8/25	1,549.3	1,048.8	.907	.394	-171.2	825.9
8/27	1,211.0	413.5	1.680	.533	1,955.5	1,191.2
9/10	3,883.9	1,403.4	.348	.146	-246.4	662.6
9/15	1,070.9	683.7	1.218	.881	-507.4	852.6
9/21	777.0	628.7	2.944	3.440	662.4	1,655.0
9/28	2,919.4	3,062.4	.704	.763	2,091.3	2,019.2
10/2	4,131.0	2,578.9	.597	.429	-1,306.3	1,232.0
10/16	1,135.6	709.3	1.099	.951	346.2	704.6
10/21	1,567.4	1,211.8	1.460	1.740	413.6	1,319.6
11/6	2,668.0	2,818.9	.345	.403	-337.7	450.3
11/16	575.0	430.5	.966		3,382.8	
11/19	7,854.0		.107		-378.6	
1/6	448.4		.691		233.3	
1/22	532.0		.222		-27.1	
2/26	86.3		.305		4.7	
2/28	29.3		.242		4.6	
3/19	11.2		0		0	

calculation of part B of the formula was eliminated and the square root of part A of the formula was taken as the standard error of the estimate of $\hat{N}_i$.

Discussion

When making population estimates it is important to consider exactly what population it is you are measuring. In the case of this study any bird on site was available for capture, however no bird's movements were restricted to the sampling site alone. Thus, the population being measured was that of *P. domesticus* exploiting the sampling site. No spatial restrictions could be placed upon this population.

While the stockyard at Seymour covers only a little more than an acre, there were always a number of *P. domesticus* on site. During the winter as few as a dozen birds were observed there. The largest number of birds observed on site at one time was estimated to be near 200. While the standard errors of the population estimates of Table IV are too large to allow precise estimation of the size of this population, it is clear that this site was exploited by several thousand individuals in the course of the summer. This illustrates the problem inherent in population estimates based on observation alone.

The fact that the standard errors of the population estimates remained rather high throughout the sampling period, in itself suggests something about the population under study. If this were a population of breeding adults, there should have been little population turnover. Therefore, as banding continued throughout the study, a greater proportion of birds should have been banded after each sample. This should have been reflected by successively higher percentages of recaptures and lower standard errors for population estimates. Since this phenomenon is not observed, the population under study must have been extremely large in comparison to sample sizes and/or the population must have had a fairly high rate of turnover.

Another striking characteristic of this population was the tremendous fluctuation in population size over relatively short periods of time. To demonstrate this more vividly the population estimates of Table IV are graphed in (Fig. 1). It is clear that these fluctuations were too extreme to be accounted for by mortality and fecundity. Only very high rates of emigration and immigration could have accounted for the high rate of population turnover. This was also reflected by the very low values estimated for $\hat{\phi}_i$ and the very high estimates for $\hat{B}_i$ (Table IV). Estimates such as these would only have been characteristic of an extremely mobile population. These results may at first appear to contradict the general opinion that *P. domesticus* is extremely sedentary. However, these results imply only that organisms entered or left the population exploiting the stockyard, and they say nothing about the total spatial distribution of the study population. Therefore, it is possible that organisms may have abandoned use of the study site in favor of other sites and still maintained a total range of only a few miles. This would have required abundunt resources and very high population densities. The general area adjoining the study site easily could have provided these resource requirements, and high population densities are characteristic of this species. However, in light of these population estimates it is not possible to maintain that this was an urban nesting population. Adults are

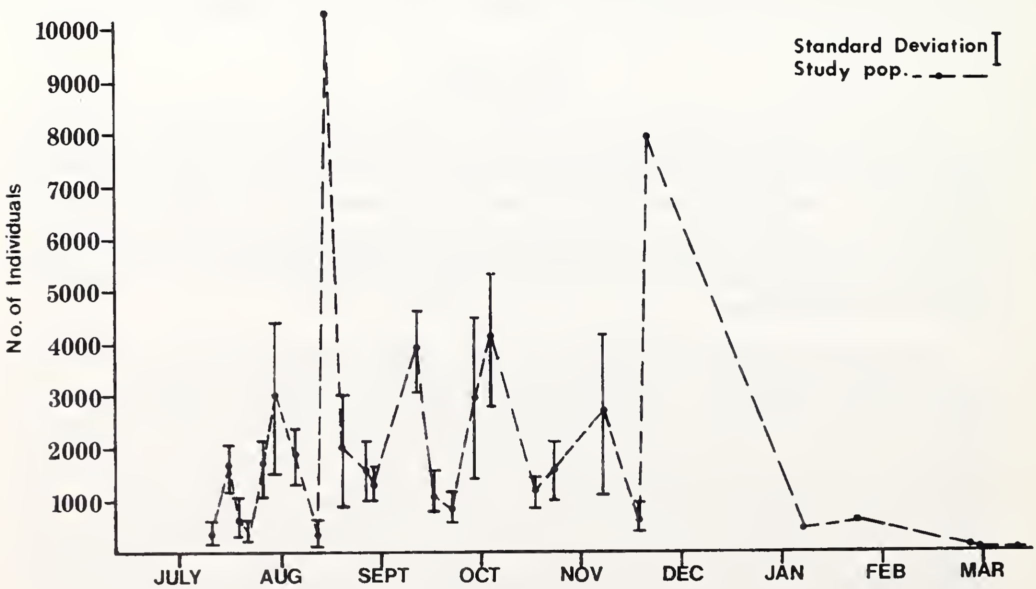

FIGURE 7.

much less mobile than juveniles and have a very strong attachment to the nesting site. The rate of population turnover was much higher than could reasonably have been expected for a nesting population. A great majority of the birds exploiting this site were no doubt recruited from flocks of juveniles in the adjoining fields. This assumption is supported by the very high ratio of juveniles to adults. Table V gives the percentage of adults and the percentage of juveniles captured in each sample along with the standard error of each of the percentage estimates. These statistics are graphed in (Fig. 2). Data from samples later than January were not used since first year birds become indistinguishable from adults of the year before. The age composition expected of a closed population was calculated from Will's composite model of population increase (8) and graphed in (Fig. 2) for comparison. While the highest juvenile to adult ratios occurred August through September just as the model predicts they should have, the extreme skew in favor of juveniles was much higher than could reasonably have been expected from the model. Considering the accepted scheme of seasonal dispersal, the proportion of junveiles at an urban nesting area should have been lower than predicted by Will's model. On the other hand, the proportion of juveniles in the outlying fields should have been higher than predicted by this model. On this basis it is suggested that a large complement of the population exploiting the stockyard was composed of *P. domesticus* recruited from foraging field flocks. Yet even if this is taken into consideration, the ratios were so skewed that the possibility of trapping selectivity for juveniles warrants consideration. Unfortunately, no work addressing this concern exists.

TABLE V *Proportions of Adults and Juveniles in the Study Population*

Date	Percentage of Adults	Percentage of Juveniles	Standard Error
6/30/77	66.7	33.3	10.3
7/9/77	27.3	72.7	7.8
7/17/77	28.3	71.7	6.6
7/24/77	12.5	87.5	3.4
8/11/77	28.6	71.4	9.9
8/13/77	1.3	98.7	1.7
8/18/77	5.0	95.0	4.9
8/27/77	0.0	100.0	1.1
9/10/77	2.1	97.9	1.2
9/15/77	0.0	100.0	2.2
9/21/77	0.0	100.0	3.0
9/28/77	0.0	100.0	2.0
10/2/77	8.2	91.8	3.9
10/16/77	14.3	85.9	6.6
10/21/77	8.0	92.0	5.4
11/6/77	11.6	82.1	7.2
11/16/77	21.4	78.6	11.0
11/19/77	20.6	79.4	4.1
1/6/78	25.0	75.0	10.8

Calculated from TABLE I. Samples taken after January and samples which were selective for juveniles are not included.

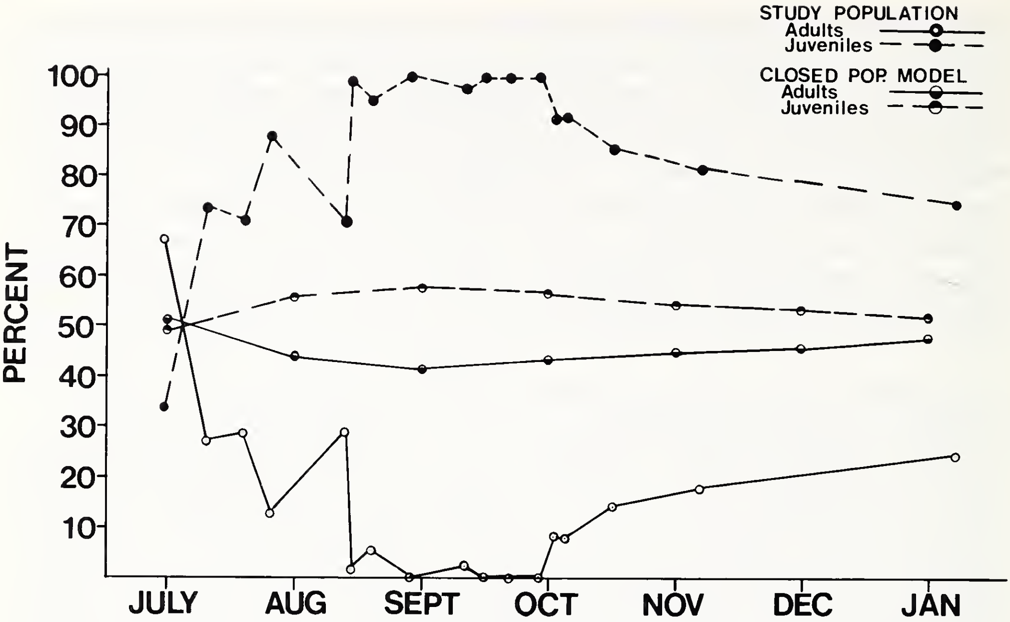

FIGURE 2.

Juveniles from the crop fields were probably attracted to the study site by the availability of livestock feed. However, if juveniles were attracted to the study site only during the day to feed, they could not have become involved in the transmission cycle of SLE, since *Culex pipiens*, the presumed mosquito vector, is a nocturnal feeder. It is therefore of significance that juveniles also seemed to be attracted to this site by the bank of trees on the south side of the study site which they used as a nocturnal roost. Very few roosting sites were available in the crop fields in the surrounding area and no doubt many juveniles were forced to return to town to roost at night. While *P. domesticus* normally roost in the crop fields if roosting sites are available, daily movements back to town for roosting are not unknown. North (5) briefly mentions observing this phenomenon in Oklahoma.

This daily dispersal pattern would have resulted in very high densities of birds at the study site during a critical period. It seems possible that these high densities may have contributed to the amplification of SLE virus in this area. This relationship clearly warrants future investigation.

The data collected in this study also suggests that urban sampling sites which exhibit high juvenile to adult ratios are preferable to other urban sites and this may be used by arbovirus surveillance personnel as a criterion for selecting future sampling sites.

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