# DEER DENSITIES IN LA MICHILIA: A REPLY TO GALINDO

SONIA GALLINA AND EXEQUIEL EZCURRA

*Instituto de Ecologia, A.C. Apartado Postal 63, 91000 Xalapa, Veracruz, Mexico*
*Centro de Ecologia, Universidad Nacional Autonoma de Mexico, Apartado Postal 70-275, 04510 Mexico, D.F., Mexico*

This paper is in reply to Galindo's (1992) recent note in *The Southwestern Naturalist* in which he criticized our studies of deer densities in Michilia Biosphere Reserve, Durango, Mexico (Ezcurra and Gallina, 1981; Gallina, 1984*a*, 1984*b*, 1986, 1988). His major criticism was that our sampling to estimate densities of white-tailed deer (*Odocoileus virginianus couesi*) from fecal counts was not random. This is simply not true. In our original paper (Ezcurra and Gallina, 1981) we stated that "in 1976, 20 temporary transects were randomly established on the study area (both the location and the direction of the transects were random, with the restriction that the direction could be changed if the transect fell in an inaccessible region)." We then described how these transects were increased to 26 in 1977, and finally established as 16 permanent transects in 1978, making clear that, in all years, the procedure followed a random design within the study area, which comprised 1,878 ha of open pine-oak forest "where deer had been previously observed, both directly and indirectly." This area was our sampling universe, and all our results were referred exclusively to this zone, because our objectives were not to know the exact population density in all the Biosphere Reserve, but to know the tendencies of the population parameters through time and to detect the associated factors. Had we implied that our sample was representative of the whole reserve, then Galindo's criticism of nonrandomness would have had support. But this was not the case. Because we were sampling an area of good habitat, we were cautious not to extrapolate our results to the larger region. Within the sampling universe, the location of transects was random.

We do not understand why Galindo a priori discounts deer migration within the reserve as "unlikely." The study area, and the reserve as a whole, is not enclosed and deer are free to wander in and out. In our first paper we were not aware of the potential influence of migration on the deer population dynamics. However, after a decade of sampling, it seems clear that migration is playing a significant role (Gallina, 1990). To assume, as Galindo does, that all changes in population numbers in an open herd like the one at La Michilia have necessarily to be explained in terms of intrinsic population growth, is unfounded conjecture. Having put forth this assumption, Galindo then compares the variation in population numbers of the open herd at La Michilia with data for protected closed herds, and concludes that intrinsic growth cannot account for the population changes at La Michilia (and in a non sequitur deduces that our sampling procedure must therefore be wrong). We agree; intrinsic growth cannot account for these changes, but this does not prove our method wrong. Obviously, migration is playing a major part in the observed variation.

The procedure that Galindo used to calculate population growth rates is capricious and unjustified. He chose to calculate the accumulated rates taking as base year 1981, when the population counts hit their lowest numbers. Quite expectedly, the rates obtained from this calculation are very high, as they depend exclusively on an initially low number which can be easily affected by migration or random error. If, more appropriately, we calculate the annual rates of change on a year-to-year basis, the perspective changes completely (Table 1). Only in 1981 did the rates show unusually large numbers. In all other years the growth rates were below 0.2, much lower than the values reported for the Michigan herds cited by Galindo. Indeed, in four out of eight years, the rates of change were negative. Because the population counts in 1981 were extremely low (around 54 animals), the growth rate that year was necessarily sensitive to immigration increasing the effective herd size.

Finally, Galindo reported unpublished data of his own taken in 1987 that supposedly yields different results from ours. Galindo implied that the differences between his sampling and ours were due to the different methodologies. However, the comparison is confounded by two other factors: time (his data were taken in a different year) and sampling universe (he sampled a different study area). Thus, his data were not true replicates of ours, differing in only one controlled factor (the sampling method). Instead, they were pseudo-replicates, differing simultaneously in at least three variables. Galindo's supposed proof of the unsuitability of our data is unfounded. In our analysis, we compared the statistical distribution of counts with two probability density functions (Poisson and Negative Binomial). This is a robust statistical way to check the assumptions of random sampling and it allows calculation of reliable intervals of variation.

Galindo claimed that the transect length in our study was too short "and it may not have exceeded the home range diameter of even one individual." This can be tested statistically, taking into account that our sampling procedure followed a nested design (as do most transect methods used to count pellet groups). We located 20 random transects within our study area, and 40 systematic plots within each transect. In a nested design of this type, the total variance can be partitioned into two components: the between-transects variability and the within-transects component. If, as Galindo argues, our plot size would have coincided with the home range of individual deer, then our between-transect variance would have been significantly higher than the within-transect variance. But this was not the case, both variances were similar, indicating that our sampling procedure was robust. But even if our transect length was indeed too short, it would not account for a bias in the sample. It is a well-known fact in statistics that, when the plot size is too small and coincides with a pattern in the field, the variance of the sample will increase considerably, but the expected value for the sample mean ($\bar{X}$) is still the true population mean ($\mu$). Thus, for Galindo's hypothesis on the origin of our supposed overestimation to be true, not only would our transect length have had to coincide with the deer home ranges, but each one of our transects would have had to fall within an area of high deer activity, systematically avoiding the areas of low activity. With random transects the probability of this happening is vanishingly small.

In another part of his paper, Galindo suggested that one of us reported unusually large numbers for the endangered peninsula mule deer at the Sierra de la Laguna, Baja California (Gallina, 1988). However, the high numbers he referred

TABLE 1—Growth rates calculated by Galindo (1992) and those calculated from our original data.

| Year | Density | Annual rate | Galindo's rate |
|---|---|---|---|
| 1976 | 33.11 | −0.496 | |
| 1977 | 20.17 | 0.001 | |
| 1978 | 20.19 | −0.732 | |
| 1979 | 9.71 | −0.273 | |
| 1980 | 7.39 | −0.946 | |
| 1981 | 2.87 | 2.089 | 2.080 |
| 1982 | 23.17 | 0.183 | 1.130 |
| 1983 | 27.81 | 0.503 | 0.551 |
| 1986 | 46.00 | | |

to were the result of a preliminary sampling discussed in a symposium in Mexico, and reported in the proceedings. Well before Galindo published his criticism, Gallina's final estimates had been published elsewhere (Gallina et al., 1991): the estimated mean was 37 deer/km$^2$ for the pine-oak forest habitat in the highest part of the Sierra de la Laguna. This estimate coincides well with the densities reviewed by Galindo for other areas. Furthermore, Gallina et al. (1991) noted that this second estimate still seemed high relative to the rest of the region. The high counts were attributed to the fact that the pine-oak forest lies in the most protected part of the Sierra, that it is a mesic and productive habitat, and that it is extremely inaccessible to hunters. As with the deer counts at La Michilia, Gallina et al. (1991) took great care not to extrapolate these densities to the whole region. Gallina et al. (1991) concluded that both the deer population and the pine-oak forest in the Sierra de la Laguna are extremely fragile and need protection "as an area under conservation schemes." For some reason, Galindo cited preliminary data from a local symposium, and failed to cite final data published in an international journal.

We do not wish to uncritically defend our results. A long time has passed since 1981, and if we were to redesign the sampling procedure for La Michilia we would take many more aspects into consideration, mostly as a result of our own experience with the problem. At the time we published our paper, the available information suggested that the defecation rate of deer (12.7) was quite constant. Recent papers, however, have shown it to be much more variable than previously thought (e.g., Rogers, 1987), and we are now taking this effect into account. A student of ours, for example, found that a defecation rate of 27 gave the best fit between fecal counts and direct observations in the Pacific deciduous forests of Mexico (Mandujano, 1992). The lack of a good estimate for the defecation rate originally used, however, is only a minor problem in our data. The value of the Michilia long-term study is the analysis of year-to-year variation in deer activity as estimated by pellet counts. Adjusting for a higher defecation rate means only multiplying the numbers by a constant, but the relative counts from one year to the next, and their standard errors, remain proportionally the same, and the discussion of our papers will not suffer changes.

Finally, Galindo implied that our studies could contribute to improper management policies. If government managers take our studies seriously, then hopefully they would pay attention to the main conclusion of our 1981 paper: "This study shows an urgent need to control hunting and to take strong measures against poaching. Only in this way will it be possible to protect the white-tailed deer and allow their population to reach a stable and adequate level." Likewise, any government officer interested in the management of the peninsula mule deer would, hopefully, pay attention to the two main recommendations of Gallina et al. (1991) and seriously consider decreeing a protected area in the Sierra de la Laguna, while controlling poaching in the region.

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