CLARIFICATION OF CIRCULAR HOME RANGE PROBABILITY ZONES BASED ON STANDARD DIAMETERS

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Abstract: Two key papers developing the concept of statistical home range use identical terminology to present different definitions of similar but not always identical concepts. Because of this, minor errors in the assignment of probabilities to circular home range zones have been perpetuated. We clarify ambiguous terminology and assignment of probabilities to circular home range zones.

Uniform and correct definitions of technical terminology are crucial to any field of science. Probabilities assigned to home range zones must be adequately defined in home range and animal movement studies. In the case of circular home range probability zones, such definition is mandatory for proper interpretation of research using circular home range measures, and for correct comparison of circular to other models of home range. Minor errors in the assignment of probabilities to circular home range zones exist (White 1964, Havera and Nixon 1978). These errors are apparently perpetuations of errors and confusing terminology found in two papers seminal to the field of statistical home range modelling (Calhoun and Casby 1958, Harrison 1958). We clarify the use of "standard diameter" by these authors, and correct and clarify the assignment of probabilities to circular home range zones.

Both Harrison (1958) and Calhoun and Casby (1958) assume that for a set of loci $\{(X_i, Y_i)\}$, where X and Y are normally distributed, $SD_X = SD_Y$, and $r_{xy} = 0$, home range can be described as circular probability zones with center $(\bar{X}, \bar{Y})$. These zones are expressed in terms of standard diameters or standard radii calculated from the distributions of the loci about their center $(\bar{X}, \bar{Y})$. Confusion results because the two papers present different probabilities of use for the 1 standard diameter zone (and hence other zones). Calhoun and Casby (1958) determined circular probability zones assuming a bivariate normal distribution of loci about the center of activity. Their standard radius (Fig. 1) equals the univariate standard deviations of X and Y:

$$SD_X = \sqrt{\sum_{i=1}^{n} \frac{\bar{X} - X_i}{n-1}} \text{ and } SD_Y = \sqrt{\sum_{i=1}^{n} \frac{\bar{Y} - Y_i}{n-1}}$$

They assign the probability $P = 0.394$ to the event of a locus (X_i, Y_i) falling within the circle of 1 standard radius. This probability is approximately correct, but may be slightly adjusted to $P = 0.393$ (Beyer 1966:154-156).

Harrison (1958) defined the standard diameter of a circular home range as the square root of the mean square of all diameters. Hence, Harrison's standard radius is the standard deviation of the distances (D_i) from all loci (X_i, Y_i) to their center:

$$D_i = \sqrt{(\bar{X} - X_i)^2 + (\bar{Y} - Y_i)^2} \text{ and}$$

$$SD_D = \sqrt{\sum_{i=1}^{n} \frac{\bar{D} - D_i}{n-1}}$$

Observing that his data yielded distributions of capture diameters that closely approximated a normal distribution, Harrison stated "We would, perhaps, expect a normal surface, but in fact a normal curve gives a better fit..." (1958:196). He then assigned the 1 standard diameter home range zone the probability $P = 0.683$. We believe he intended to describe the circle with center $(\bar{X}, \bar{Y})$ and passing through the point $(\bar{X} + SD_X, \bar{Y} + SD_Y)$ (Fig. 1). If one assumes a bivariate normal probability density function, as did Calhoun and Casby (1958), the probability for this zone is $P = 0.628$ (Beyer 1966).

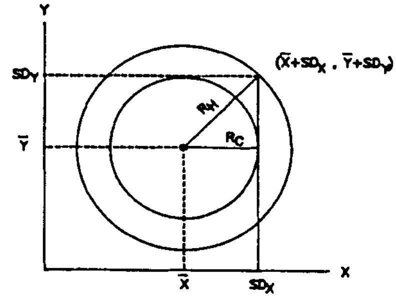

Fig. 1. Standard radii and 1 standard diameter probability zones of circular home ranges. The smaller circle (radius R_C) is Calhoun and Casby's (1958) 1 standard diameter zone. They assumed a bivariate normal distribution as the probability density function of loci; thus, the probability of a locus occurring within that circle is $P = 0.393$. Harrison (1958) assumed a univariate normal distribution as the probability density function of loci and assigned his 1 standard diameter zone (radius R_H) $P = 0.683$. Assuming a bivariate normal distribution, this probability $P = 0.628$.

Harrison's (1958) and Calhoun and Casby's (1958) definitions of circular home range probability zones are clearly not congruent, even though their terminology is. Those using these or similar models should clearly identify the parameters of analysis and assumed probability density functions in order to avoid perpetuating confusion in this matter. For example, investigations of movement distances in a home range context might use Harrison's approach, while analyses of distributions of loci over areas could follow Calhoun and Casby's use of the bivariate normal surface as the probability density function. Similar care should be taken when comparing results from "advanced" home range models (e.g., harmonic mean, kernel) to published results of circular models. Finally, this example of the confusion possible to obtain while using relatively simple statistical models of home range should provide a warning to those of us who, 30 years later, are employing increasingly complex statistical analyses.

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