

# EGG DEVELOPMENT IN REPTILES

66 • Warren P. Porter and C. Richard Tracy

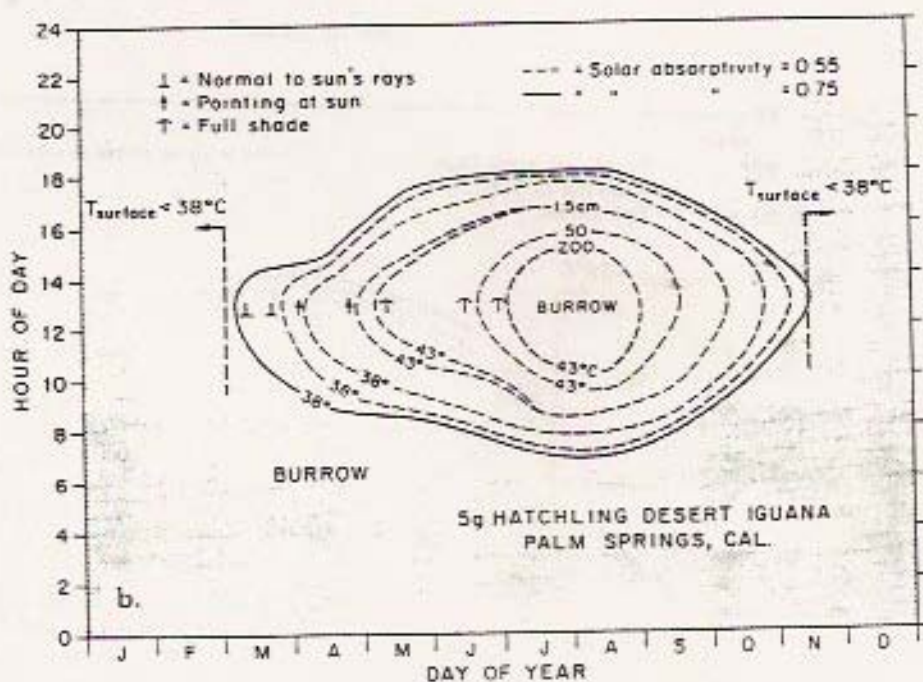
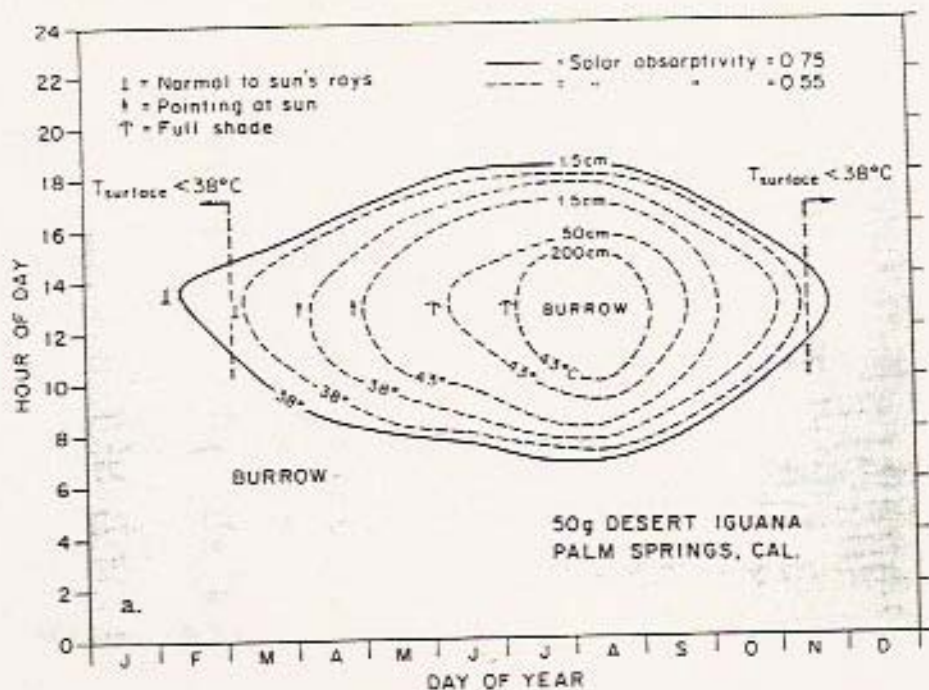
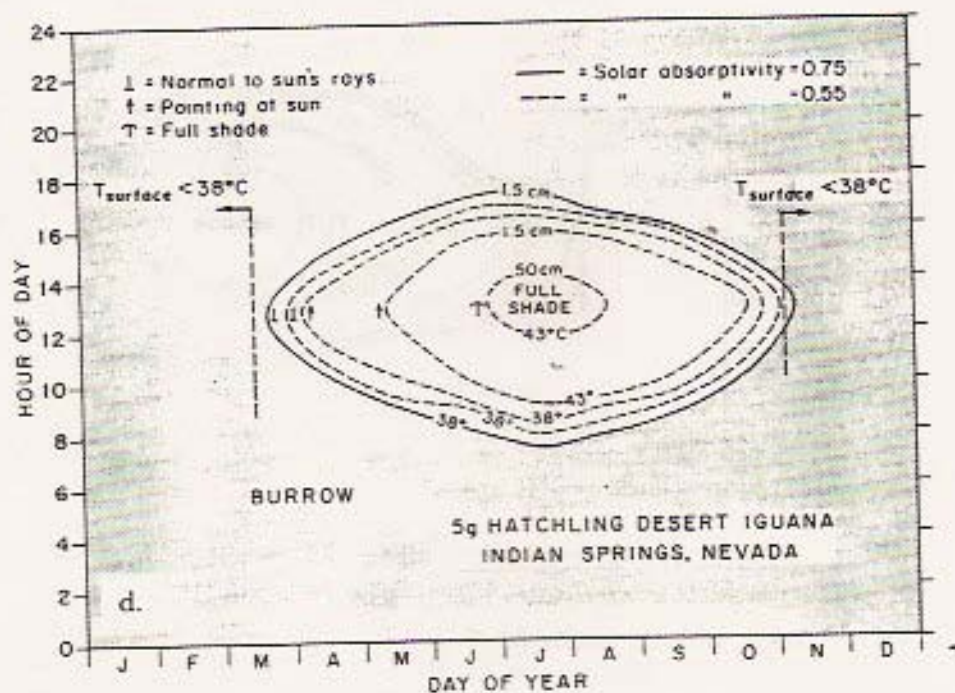
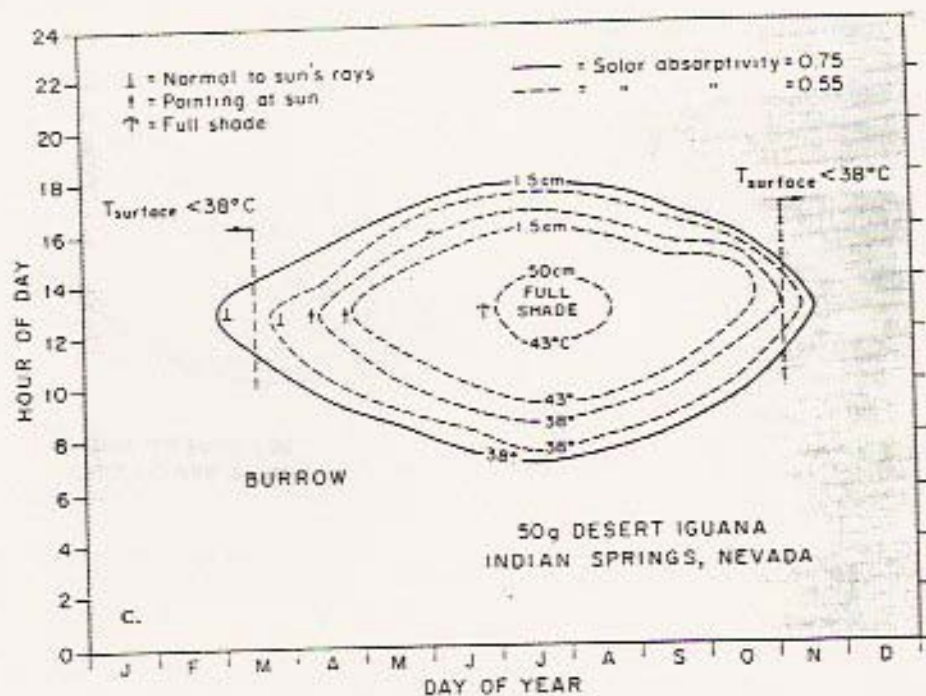


Figure 3.4 Calculated available activity time for desert iguanas in the Palm Springs, California, area for an average year. Effects of color change, posture changes, location in the microenvironment, and body size are illustrated: a, 50-g adult; b, hatchling.



tember in Smyrna, Washington (Fig. 3.12a,b). They could have a long period of activity during a midsummer day that seemed more than sufficient to permit growth and the production of eggs during the course of the year for these primarily herbivorous animals. In midsummer the du-



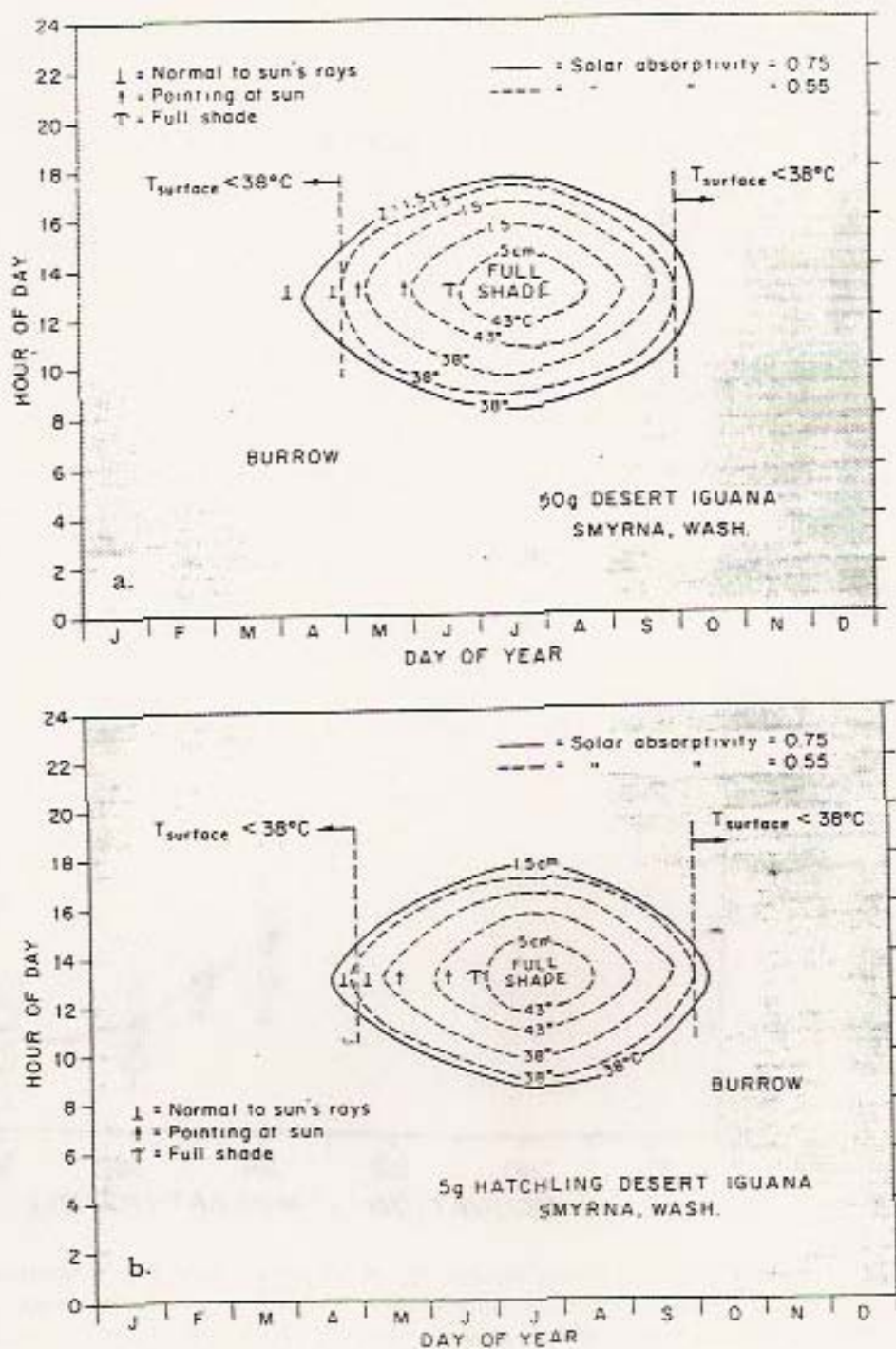
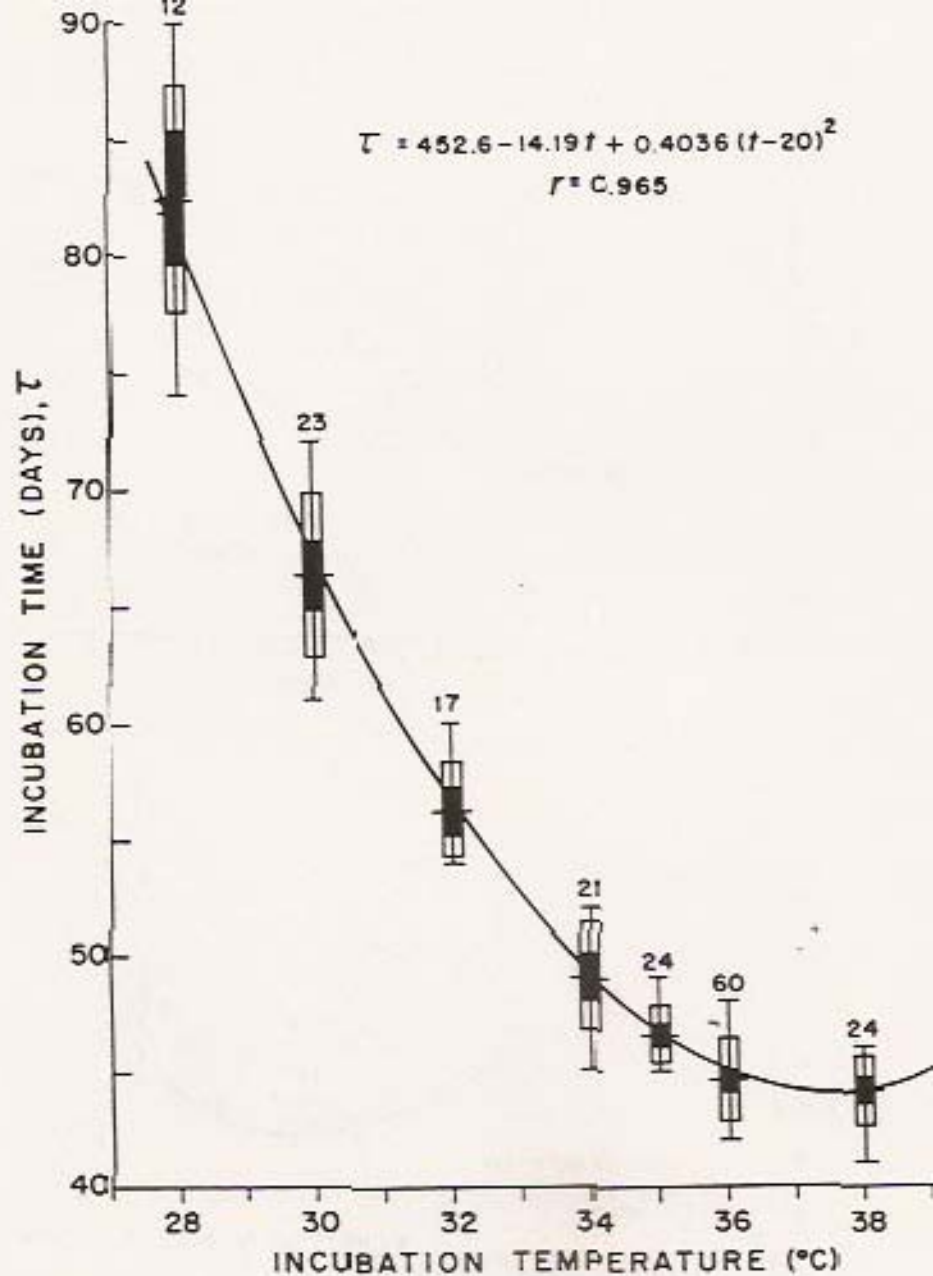
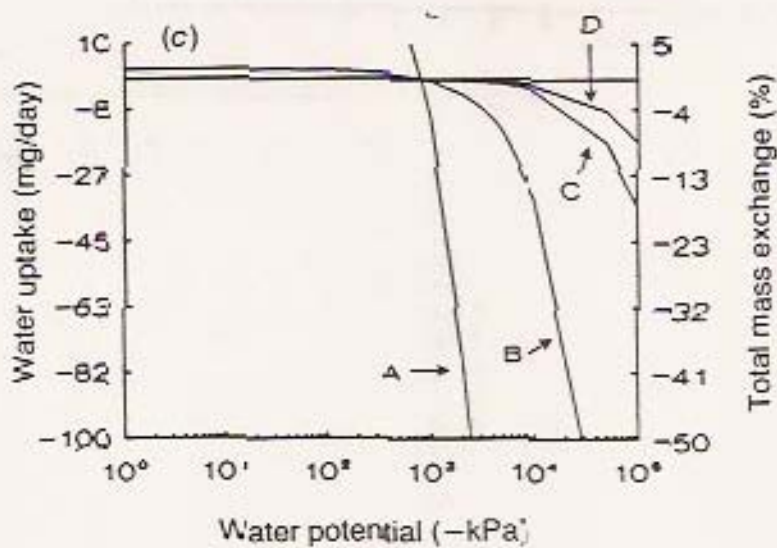
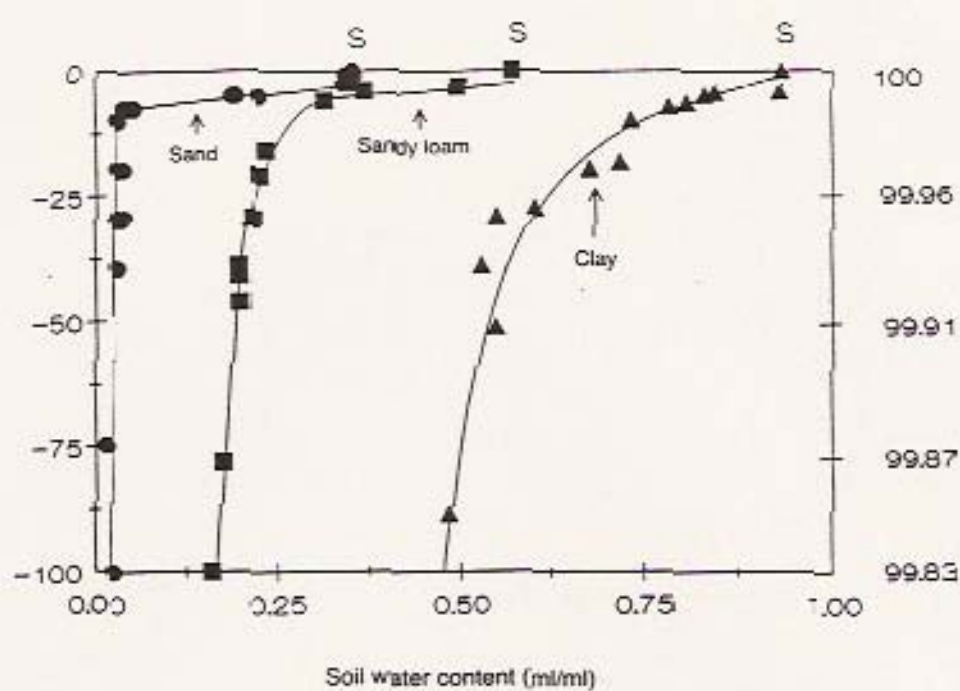
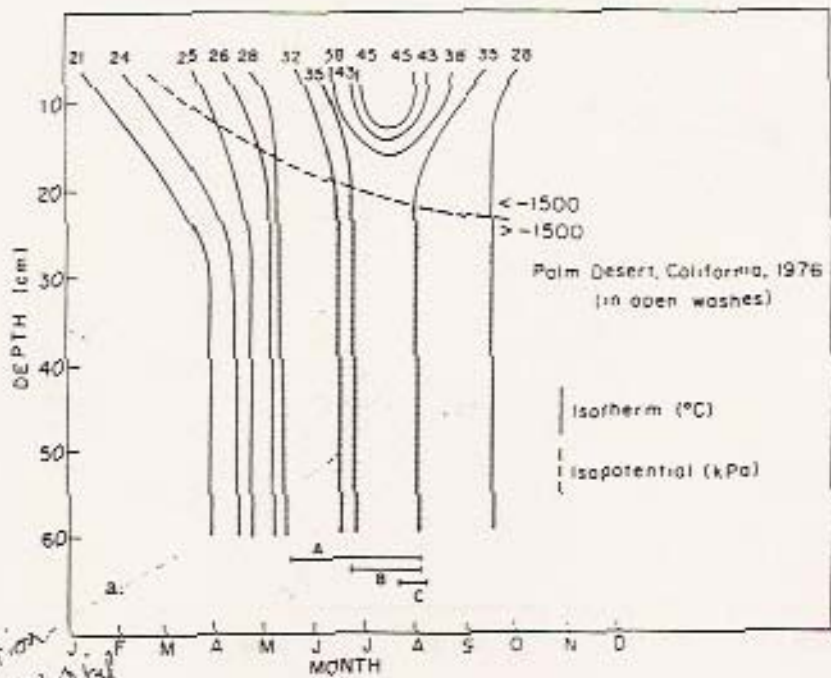


Figure 3.12 Comparison of calculated activity times for 50-g adult (a, c) and 5-g hatchling (b, d) desert iguanas outside their current geographic range. Effects of body size, color change, sun orientation, and location in the micro-environment are illustrated.

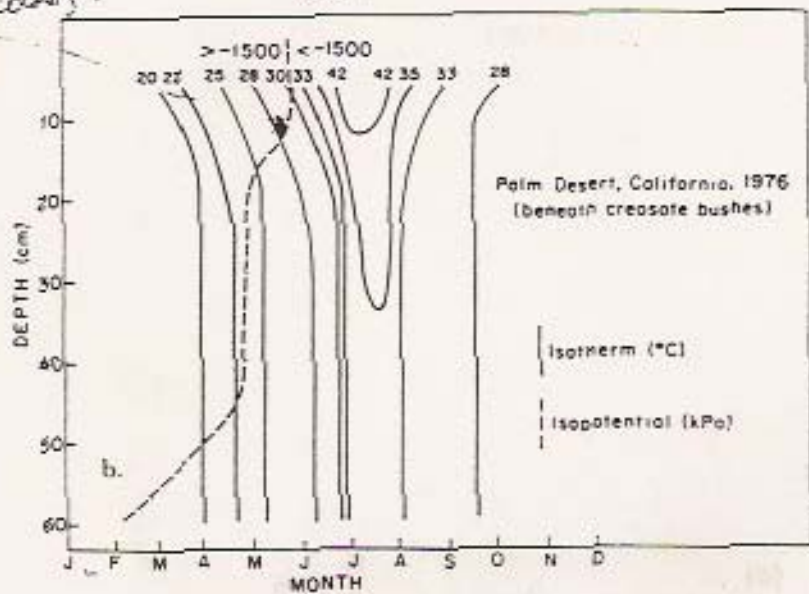


**Figure 3.14** Desert iguana egg development, time versus temperature. hormone injections or other artificial methods were used to induce egg laying. The eggs were laid in sand in laboratory cages and were placed in incubation chambers maintained at constant temperature and defined water potential (Muth, 1980. Copyright © 1980, the Ecological Society of America).

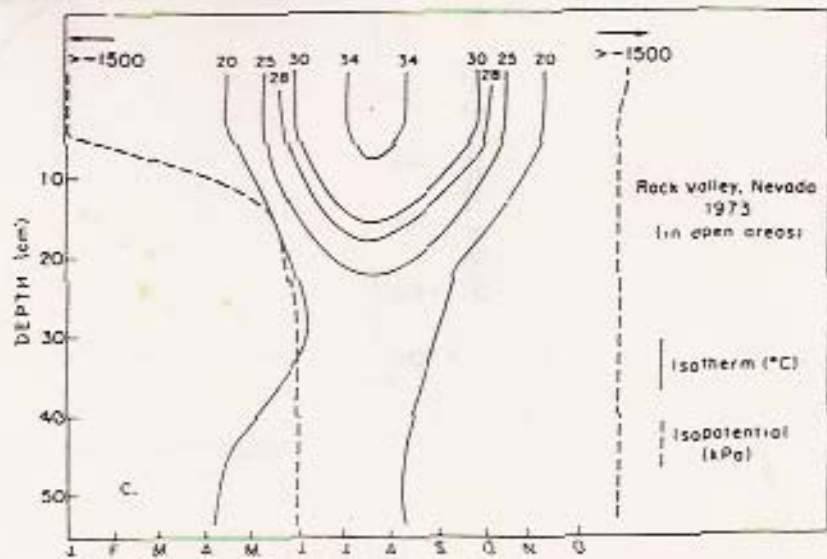




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# TEMPERATURE GROWTH & DEVELOPMENT

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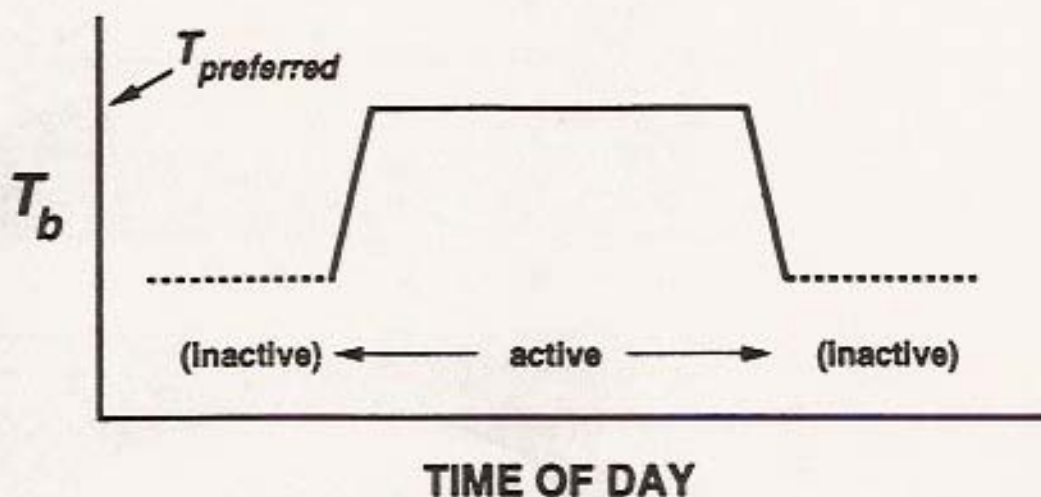


FIG. 1.—Idealized daily body temperature ( $T_b$ ) profile of a diurnal, heliothermic lizard. Value of  $T_b$  is typically high and relatively constant (around  $T_{\text{preferred}}$ ) during activity because of thermoregulation. The  $T_b$  value of active lizards often varies relatively little over the course of the activity season and among populations living in different environments. However, the amount of time lizards can attain  $T_{\text{preferred}}$  depends on the thermal environment and therefore can vary substantially both seasonally and geographically. In addition,  $T_b$  of inactive lizards is likely to vary seasonally and geographically.

## TEMPERATURE AND LIZARD LIFE HISTORIES

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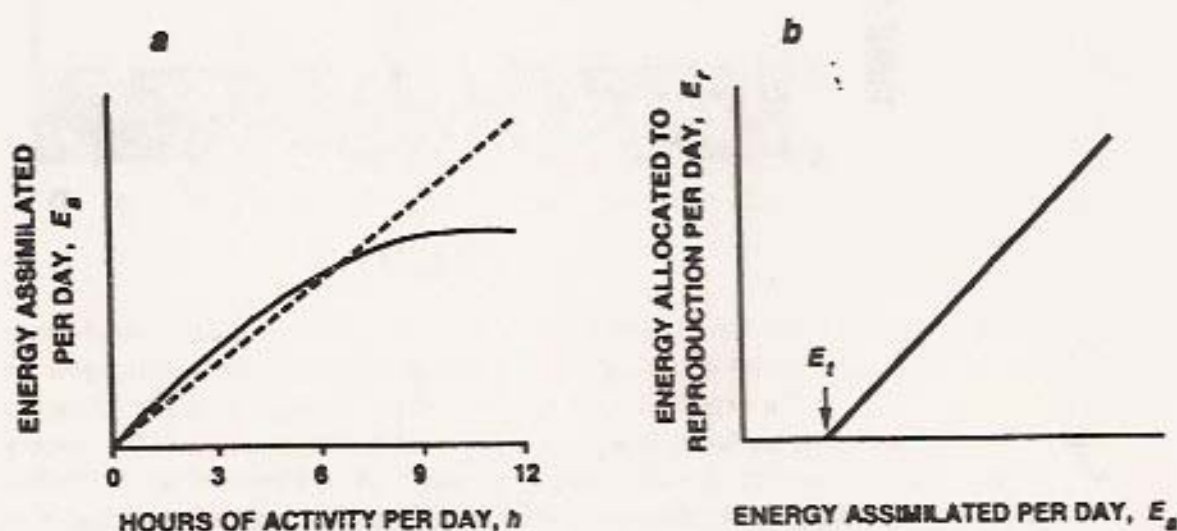


FIG. 4.—Model assumptions for daily energy assimilation and allocation toward reproduction by individual lizards. *a*, Daily energy assimilation  $E_a$  (in arbitrary units of energy) as a function of activity time  $h$ . Dashed line illustrates the special case where  $c_2 = 0$ . *b*, Amount of energy allocated per day to reproduction,  $E_r$ , as a function of  $E_a$ . Above a daily energy threshold  $E_1$  (daily maintenance requirements), a constant fraction  $f$  of each day's assimilated energy is allocated to reproduction.

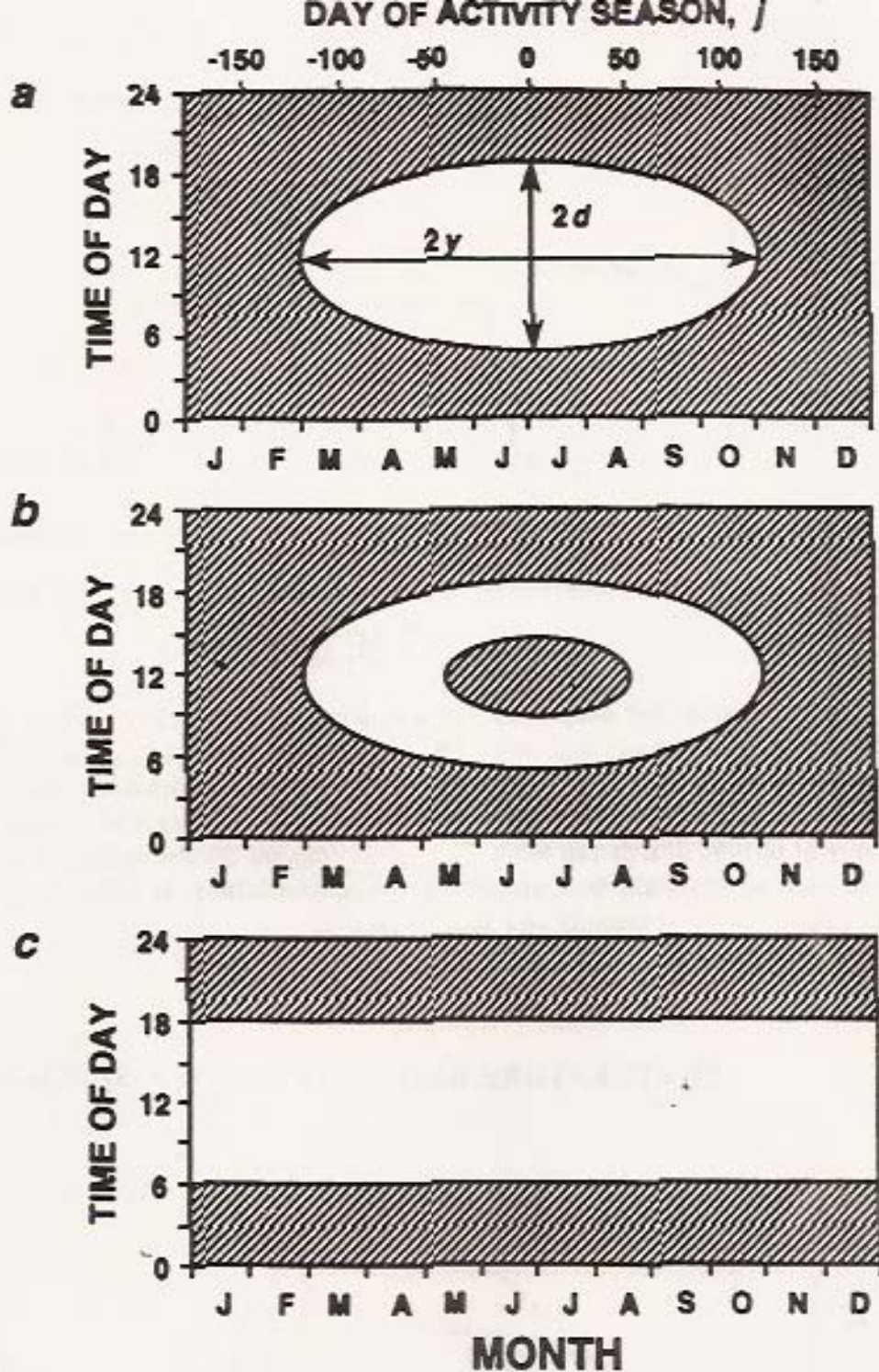


FIG. 2.—Seasonal variation in potential activity time of diurnal lizards, as determined by the thermal environment and thermal physiology of the lizard. Northern Hemisphere seasons are illustrated. *Unshaded region* indicates times when thermal conditions permit activity; *shaded region* indicates periods of inactivity. Individual lizards may not be active as often as the thermal environment permits (see, e.g., Nagy 1973; Porter et al. 1973; Simon and Mitterdorff 1976; Rose 1981; Beuchat 1989). *a*, Elliptical activity season characteristic of many diurnal temperate-zone lizards. *b*, Activity pattern often observed in lizards living in deserts or other seasonally hot environments, where high summer temperatures cause many days of inactivity (hence bimodal activity; Porter et al. 1973; Grant 1990; Grant and Dunham 1990). *c*, Rectangular activity season characteristic of some lowland tropical lizards (see, e.g., Heatwole et al. 1969; Porter and James 1979).



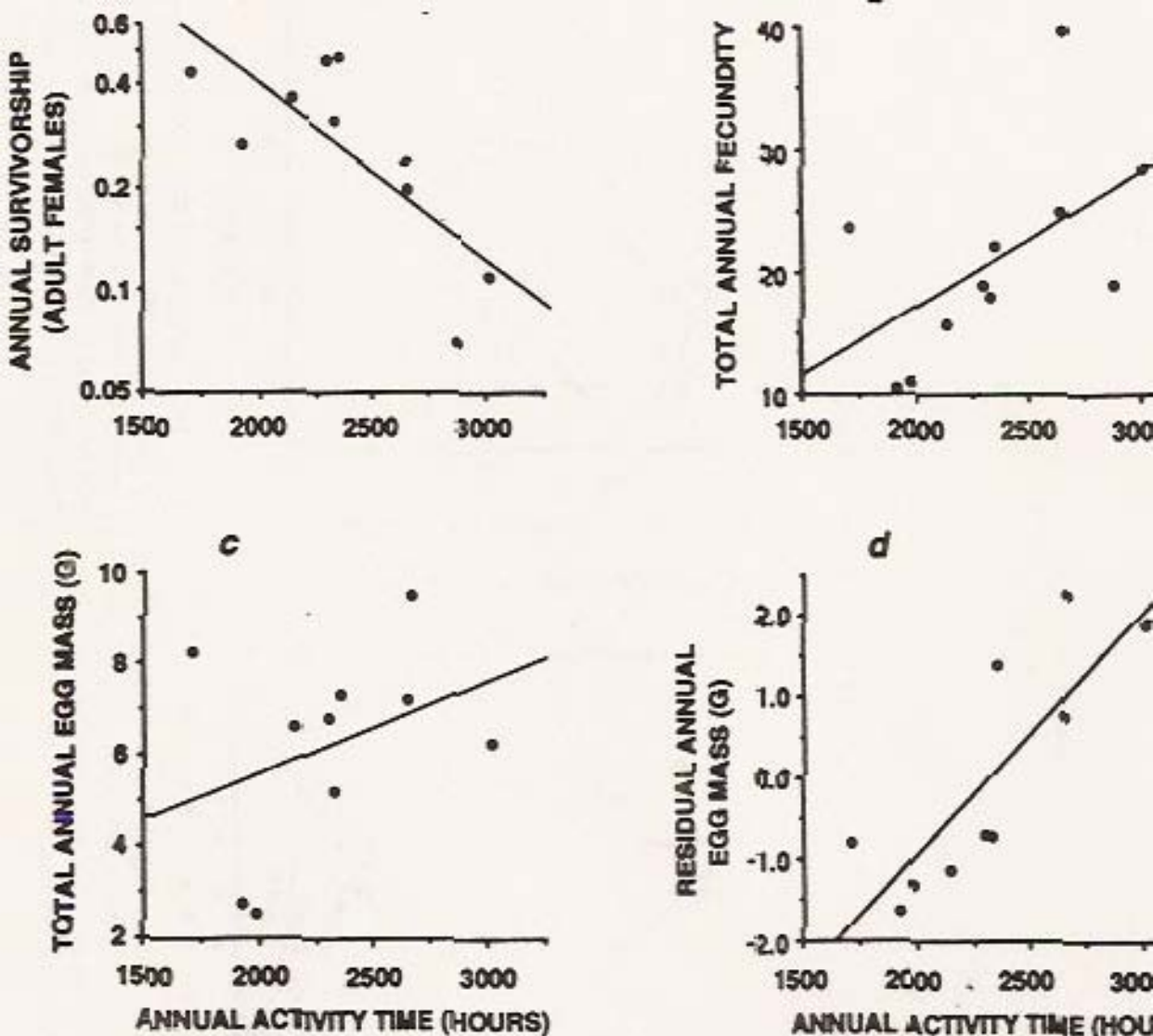


FIG. 6.—Relationships between life-history features (published data from field studies summarized in Dunham et al. 1988) and length of activity season (calculated through microclimate simulations) for North American populations of the iguanid lizard *Sceloporus undulatus*. a, Negative relationship between length of activity season and annual survival rate of adult females, plotted on a logarithmic scale (see eq. [4]) ( $r = -0.76$  for natural-log transformed data,  $N = 10$ ,  $P < .01$ ). b, Positive relationship between annual fecundity (mean number of eggs per clutch  $\times$  mean number of clutches per year) and length of activity season ( $r = 0.55$ ,  $N = 11$ ,  $P < .05$ ). c, Positive relationship between total annual egg mass (annual fecundity  $\times$  mean mass per egg) and length of activity season ( $r = 0.36$ ,  $N = 10$ ,  $P > .1$ ). d, Positive relationship between length of activity season and residual total annual egg mass after correcting for body size (mean snout-vent length) of mature females in each population ( $r = 0.82$ ,  $N = 10$ ,  $P < .005$ ). Lines show least-squares regressions;  $P$  values for correlation coefficients reflect one-tailed significance tests of a priori hypotheses based on our model.

COUNTERGRADIENT SELECTION

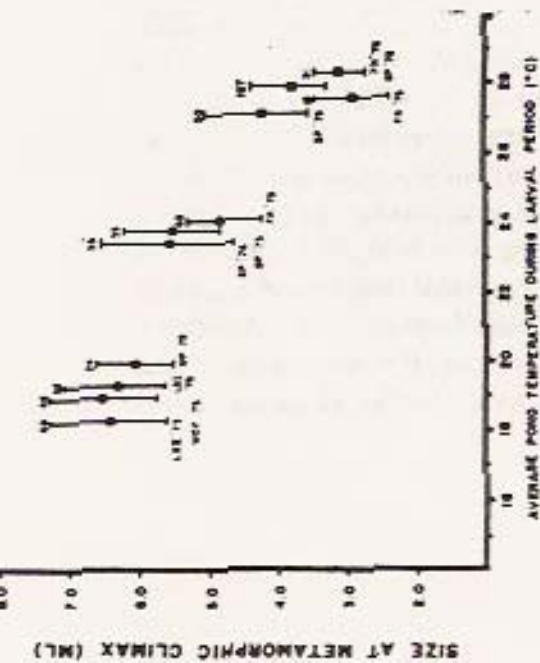


FIG. 5. Relationship of size at metamorphic climax and average pond temperature during the larval period. Average pond temperatures using days when temperature was above that at which growth ceased (Montane 14 C, Lowland 15 C). Circles = populations which overwinter, squares = populations which complete the larval period in one season. Solid point = mean  $\pm$  standard deviation, with pond and year of sample. Numbers above bars indicate sample size.

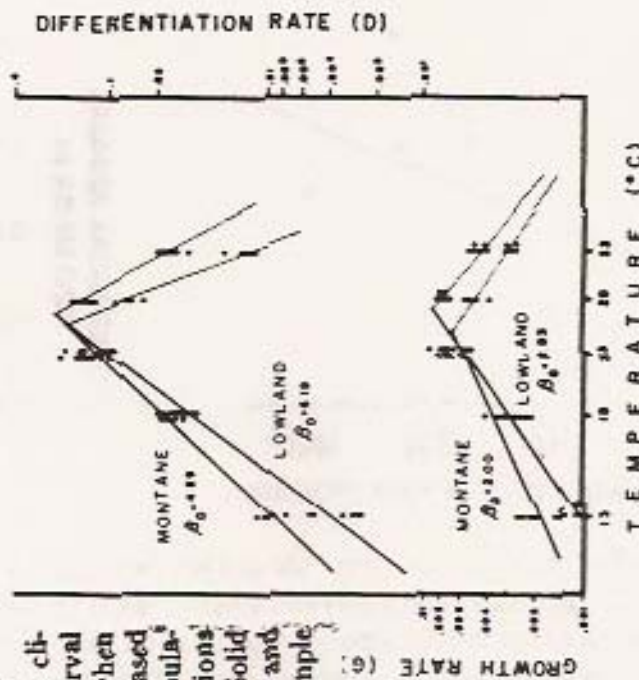


FIG. 6. Temperature dependence of differentiation rate (circles) and growth rate (diamonds) of montane (open symbols) and lowland (solid symbols) *R. clamitans*. Regression coefficients of these plots give  $\beta_0$  and  $\beta_G$ .

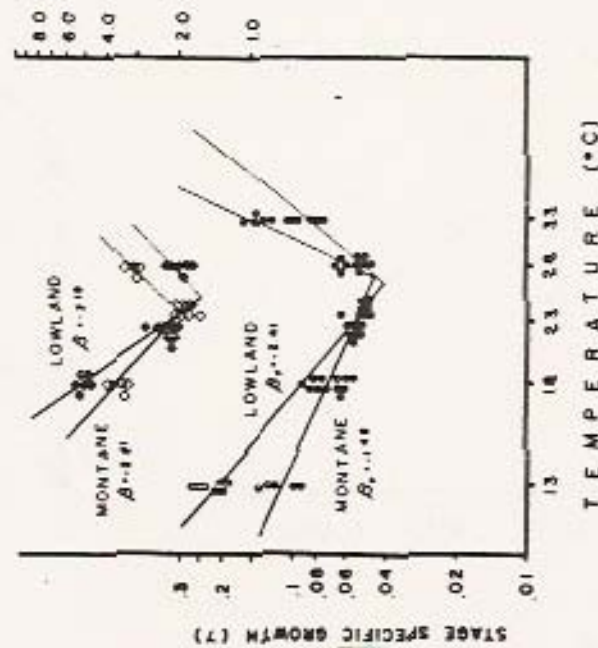
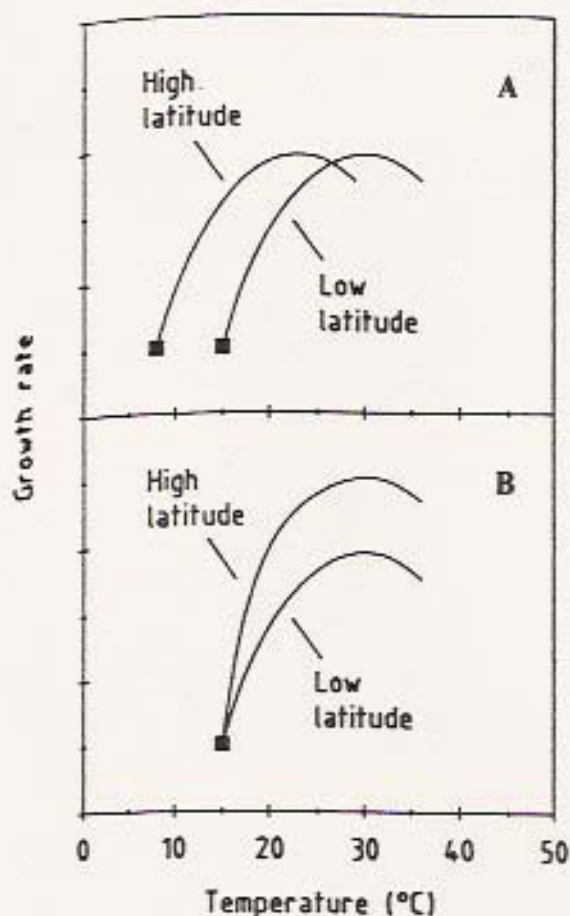


FIG. 7. Temperature dependence of stage-specific growth (circles), size at metamorphic climax (diamonds) for lowland (solid symbols) and montane (open symbols) *R. clamitans*. Regression coefficient through the linear portion of these plots gives  $\beta$ , and  $\beta$  for age at metamorphic climax. Diamonds = average size of a single replicate of four animals, circles =



**Fig. 1 A, B.** Two hypothetical compensatory adjustments to the expected temperature differences across latitudes. In each graph, the solid box represents the temperature at the onset of spawning. **A** The high-latitude population spawns at a lower temperature, and the growth rate vs. temperature curve is shifted to the left. The high-latitude population therefore grows faster at low temperatures than does the low-latitude population, but not at higher temperatures. Maximum growth rate is the same but occurs at a different temperature. **B** Both populations spawn at the same temperature and growth occurs over the same range of temperatures, but the high-latitude population has a higher capacity for growth