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Figure 1. Desert tortoises, represented by this male photographed in Joshua Tree National Park, have the greatest latitudinal distribution of any of the four North American tortoises ranging from southwestern Utah to northern Sinaloa State in Mexico, a range of 1,100 km (683 mi). Across this vast range, the desert tortoise occupies a staggering diversity of plant communities from tropical deciduous thorn scrub in Mexico, across the Mojave and Sonoran Deserts, to the edge of the Great Basin Desert and the Colorado Plateau.

Studies of reproductive output of the desert tortoise at Joshua Tree National Park, the Mojave National Preserve, and comparative sites

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The stability of any population is a function of how many young are produced and how many survive to reproduce. Populations with low reproductive output and high mortality will decline until such time as deaths and births are at least balanced. Monitoring populations of sensitive species is particularly important to ensure that conditions do not favor decline or extinction.

Turtles, including tortoises, are characterized by life history traits that make them slow to adapt to rapid changes in mortality and habitat alteration. Long life spans (in excess of 50 years), late maturity, and widely variable nest success are traits that allowed turtles to outlive the dinosaurs, but they are poorly adapted for life in the rapidly changing modern world. Increased mortality of young and adults can seriously tip the delicate balance required for turtles to survive.

The desert tortoise

The desert tortoise (fig. 1) is a federally threatened species to the north and west of the Colorado River with full protection under the Endangered Species Act (Ernst et al. 1994). The listing of the tortoise in 1990 was based on the perception of rapid population declines due largely to human-induced changes in the Mojave Desert ecosystem (Fish and Wildlife Service 1994; Lovich and Bainbridge, in press). The Recovery Plan for the desert tortoise, prepared by the U.S. Fish and Wildlife Service, identifies research on the reproductive output of the species to be a high priority for land management agencies tasked with the responsibility of recovery, and we hope, future delisting. To that end, in 1997 we initiated research on the reproductive output of the desert tortoise at several study sites in the Mojave Desert. Research support has been generously provided by the U.S. Geological Survey, Joshua Tree National Park, the California Desert District of the Bureau of Land Management, the Palm Springs-South Coast Resource Area of the Bureau of Land Management, Banning Veterinary Hospital in Banning, California, University Orthopedics, in Las Vegas, Nevada, and J. F. Kennedy Memorial Hospital in Indio, California.

Previous research on reproductive output of desert tortoises conducted by Fred Turner, Phil Medica, and others in the early 1980s demonstrated a strong correlation between clutch frequency, or how many clutches a female produces in one reproductive season, and biomass of annual plants that tortoises utilize for food. Production of annual plant biomass is in turn related to the timing and quantity of rainfall. One of our goals is to obtain more detailed data on the relationships between rainfall, annual plant biomass, and various measures of tortoise reproductive output. The information generated will provide resource managers with models relating reproductive output of tortoises to easily measured environmental variables. Such data are especially important in areas where tortoises and livestock may compete for resources such as food plants.

Study sites

The three study sites established in the spring of 1997 included Joshua Tree National Park, the Mojave National Preserve, and another in an area administered by the Bureau of Land Management (BLM) near Palm Springs, California. Two additional sites were added in the spring of 1998: one in Piute Valley, Nevada, and one in St. George, Utah, both on lands administered by the Bureau of Land Management. Studies in Utah are being conducted in cooperation with U.S. Geological Survey Research Biologists Todd Esque and Dustin Haines. The sites in the Mojave National Preserve and near Palm Springs are located in active cattle grazing allotments.

Methods

Thirty-six female tortoises were equipped with radio transmitters in 1997 (fig. 2), located at weekly or biweekly intervals April-July, and x-rayed (fig. 3) to determine the presence of shelled eggs. The x-ray procedure exposes tortoise embryos to radiation

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Figure 2. Research biologists use many tools to collect data. Desert tortoises, like this female photographed in Joshua Tree National Park, are frequently equipped with radio transmitters for projects that require tracking and relocation of individual animals. Valuable data on movements, home range and other behaviors are obtained from studies using this technology.

doses much lower than internationally accepted levels established for developing human embryos (Hinton et al. 1997). Studies in the Mojave National Preserve were complemented with the use of ultrasound technology to determine the presence and size of follicles (eggs) prior to their detectability using x-radiography.

Results

At the Palm Springs site, 9 out of 10 females produced a total of 72 eggs in the 1997 reproductive season (one produced no eggs). Of these nine females, six produced second clutches and at least one produced a third clutch. Mean size of first and second clutches was 4.33 and 5.00 eggs, respectively. The earliest date of egg laying occurred April 18-23, about one month earlier than previously reported in the literature. In contrast, at sites nearby in Joshua Tree National Park, only one of eight females produced a clutch (five eggs), and she occupied the wettest microhabitat sampled that year. Most of the other monitored tortoises in the park occupied areas that were in the second year of drought with little or no production of annual food plants. Modest germination at the Mojave National Preserve allowed 12 of 18 monitored tortoises to produce single clutches (there were no subsequent clutches) in 1997. Differences among sites appear to be related to patterns of rainfall and annual biomass production, as expected.

Of particular interest is the fact that the average annual number of eggs produced per female at the Palm Springs site was more than double (8) that of tortoises at Mojave National Preserve (3.58). Such wide variation in annual reproductive output should be accounted for in any future population viability analyses for the species. Our results for 1997 have another aspect worth noting in that they underscore the fact that even well-protected natural areas like parks and preserves cannot protect sensitive species from the vagaries of climate variation. In this case, tortoises at a relatively wet and productive industrial site produced far more eggs than tortoises in fully protected, but drought-stricken, areas.

The results for 1998, an El Niño year, were remarkably different. At Palm Springs, 12 of 13 tortoises laid eggs and all 12 that produced eggs laid second clutches; about one-third produced triple clutches. Of interest is the fact that mean first and second clutch sizes did not differ from a statistical standpoint between 1997 and 1998 at Palm Springs. At Joshua Tree National Park, seven out of seven females laid eggs, and five produced second clutches. These differences with 1997 data seem to reflect the wet and highly productive conditions fostered by El Niño's rains. Rain that fell in late summer and early fall gave tortoises an opportunity to drink and feed on "summer" annuals prior to hibernation. Upon emergence from hibernation they were presented with a veritable cornucopia of winter annual food plants that germinated as a result of continued El Niño rains (fig. 4, page 24). Thus, to date our studies suggest that in years when tortoises have an abundance of food plants, more tortoises may reproduce and produce more clutches, but that they produce a relatively constant clutch size, regardless of conditions.

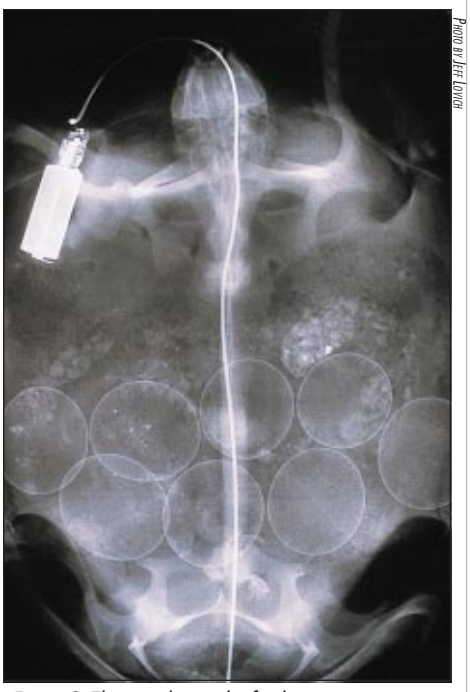

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Figure 3. This x-radiograph of a desert tortoise collected near Palm Springs (California) on 20 May 1997 clearly shows the outlines of eight shelled eggs. Females retain shelled eggs for 3-6 weeks prior to depositing them in nests. Nests are often constructed in the mouth of a tortoise burrow.

Future plans

The study will continue through the 1999 reproductive season at all five sites and through the 2000 season at Joshua Tree National Park and the site near Palm Springs. The data generated will provide natural resource managers with locally and regionally specific information on reproductive output of this threatened species and its relationship to environmental determinants such as rainfall and annual plant biomass production. Ultimately, these data can be used to build more accurate demographic models to better understand the recovery potential of desert tortoises. **PS**

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PHOTO BY KATHIE MEYER

Figure 4. In the spatially and temporally variable environment of the desert, resources such as rain and the annual plants that germinate in response to precipitation fluctuate widely. This photograph, taken in Joshua Tree National Park, shows how abundant annual plants can be in some years. In other years or places germination may be sparse or absent. Animals like the desert tortoise need strategies to cope with these large variations in productivity.