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The Search for Sources of Potential Toxicants in Desert Tortoises: Results of a Pilot Project Incorporating Surficial Materials and Plants from Three Areas in Southeastern California

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Diseases are known contributors to rapid declines in desert tortoise (*Gopherus agassizii*) populations in some parts of the southeastern California deserts. Elevated levels of potential toxicants (e.g., Cd, Cr, Hg, Ni, Pb) have been found in some ill, dying, and recently dead tortoises (Jacobson et al. 1991, Homer et al., unpublished data) and may have exacerbated poor health. The sources of the potential toxicants have not previously been investigated. For this pilot project, we evaluated levels of chemical elements in soils where tortoises live and in common forage plants, including forbs, grasses, and herbaceous perennial species. We collected 46 plant samples, representing 22 different species, and 107 surficial samples (rock, soil, and active wash sediment). The plants and surficial materials were collected from one of three localities: (1) a traverse between the Rand mining district (Randsburg, Red Mountain, and Johannesburg) and the Desert Tortoise Research Natural Area in eastern Kern County, to identify effects of mining; (2) selected areas within the Goldstone Deep Space Area at Fort Irwin, San Bernardino County, to identify effects of past military activities and a natural playa lake environment; and (3) the Chuckwalla Bench and Salt Creek area, Riverside County, to identify effects of an old railroad used to transport iron ore and other, lithologically-related factors.

We analyzed the dried plant material for 35 elements (Ag, As, Au, Ba, Br, Ca, Ce, Co, Cr, Cs, Eu, Fe, Hf, Hg, Ir, K, La, Lu, Mo, Na, Nd, Ni, Rb, Sb, Sc, Se, Sm, Sr, Ta, Tb, Th, U, W, Yb, and Zn) using neutron-activation analysis. For comparative purposes, we also collected samples of surficial materials and analyzed them for 41 elements (Ag, Al, As, Au, Ba, Be, Bi, Ca, Cd, Ce, Co, Cr, Cu, Eu, Fe, Ga, Hg, Ho, K, La, Li, Mg, Mn, Mo, Na, Nb, Nd, Ni, P, Pb, Sb, Sc, Sr, Ta, Th, Ti, U, V, Y, Yb and Zn) using a total-acid digestion, inductively-coupled plasma spectrometric technique. From these data, 17 elements (As, Ba, Ca, Ce, Co, Cr, Fe, K, La, Mo, Na, Sb, Sc, Sr, Th, Yb, and Zn) yielded mostly detectable concentrations in both plants and soils. We compared element concentrations in plants (on an ash-equivalent basis) with those of the substrate soil collected near each individual plant sample. We found elevated concentrations of Ca, K, and Zn in all plants, and similar enrichments of As, Co, Mo, and Sr in most species. With the exception of arsenic all seven elements are biologically active in plants. Other elements, such as Cr, Ni, and Se, are also enriched, but only in a few plants.

Of the elements studied in the pilot project, the most interesting are probably arsenic and

molybdenum, potentially toxic elements. Consumption of large quantities of arsenic- and (or) molybdenum-rich plants by tortoises theoretically could affect their health. We have no information as to the extent of arsenic-rich plants region-wide but our data suggest that this element only occurs in anomalous concentrations in scattered localities and only in some species. Arsenic anomalies were found in all three study areas, with the highest concentrations in the vicinity of the area of past and present gold mining around Johannesburg, where arsenic is a known component of the gold ores. The anomaly related to that mineralization extends southward from the mined area for about 6.4 km. Other anomalous concentrations of arsenic are probably related to normal but relatively elevated concentrations of this element in rocks of the region. In contrast to arsenic, the distributions of anomalies for elements such as lanthanum, an element that is not biologically important, are solely related to rock chemistry.

Goldstone Lake represents a specialized local chemical environment. A sample of the lake-bed material contained weakly anomalous concentrations of As, Ca, Cd, Co, Cr, Cu, Li, Mo, Ni, Sb, Sc, Sr, V, and Zn. Plants growing in the area surrounding the lake bottom are generally salt tolerant. One species found there, *Stanleya pinnata*, contained an unusually high concentration of selenium, another biologically active element that can be toxic to animals. Selenium was not found in any of the tortoise forage plants, however.

When compared to their soil substrates, most of the 22 different plant species that we analyzed show weak enrichments for a number of elements. Some of these enrichments reflect differences in substrate chemistry and some reflect the biochemical differences between plant species. For example, the samples of native perennial grass and alien annual grass were enriched in Ca, K, Mo, Sr, Zn, whereas some samples of alien annual grass also contained As, Co, and Cr. The forbs *Stylocline micropoides* and *Plantago ovata* were enriched with more than 12 elements. The impact of any of these elements acting singly or together on the health of desert tortoise populations is not yet clear. To test hypotheses concerning the potential toxicants, more surficial and plant samples need to be collected both locally and regionally, particularly from sampling control sites where tortoises are healthy and show few signs of disease. The ongoing research on potential toxicants identified in tortoise scute and bone from ill and control tortoises also needs to be integrated with our plant and surficial material data.

Literature Cited

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