Estimating radionuclide transfer to reptiles

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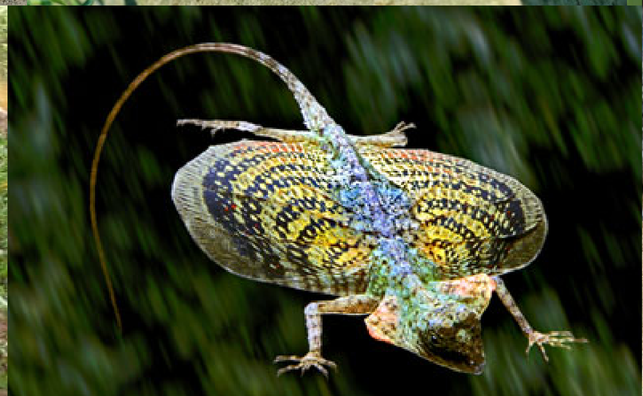
What are reptiles?

- Animals in the Class Reptilia
- c. 8000 species
  - endangered (hence protected)
- 'Types' of reptile
  - Snakes
  - Lizards
  - Crocodilians
  - Turtles, terrapins and tortoises
- Poikilotherms – external heat source (the sun)
- Keratinised scales on skin & some have shells
- Herbivores and carnivores
- Comparable vertebrates
  - Evolution – birds
  - Ecological niche – mammals

Why bother about transfer to reptiles?

AP / Steve Chen

Diversity

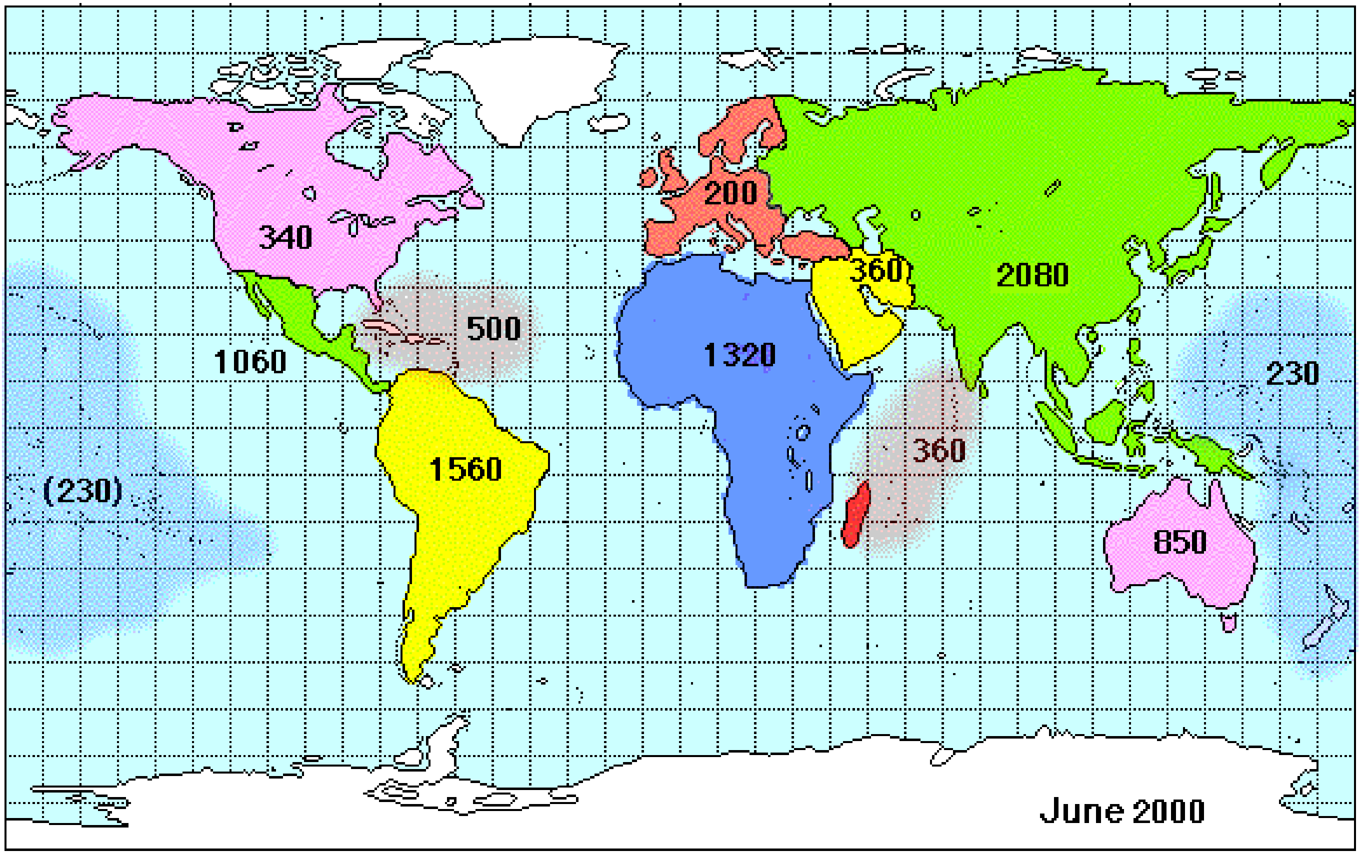


Ecosystem function

Biomass

- Mammals and birds have metabolic rates 7-10 times higher than poikilotherms of equivalent size
- Largely due to energy endotherms invest in heat production (c. 90% of intake)
- Poikilotherms therefore convert energy to biomass more economically
- If ambient temperature high enough, same food base can support higher poikilotherm biomass than endotherm biomass
- Therefore, in arid areas where vegetation growth may be insufficient for mammals, reptiles can thrive
- Reptiles can be the dominant animal biomass in these ecosystems

Likelihood of being impacted by discharges



Worldwide Diversity of Reptiles (as of June 2000)

www.reptile-database.org/db-info/diversity.html

Therefore need to understand trophic transfer

Constructing the database

- Data sources
  - Published studies
  - Unpublished reports ('grey' literature) + data
  - In-house data sets
  - Foreign-language literature
    - e.g. 'Mine' Russian-language literature – enlist a Russian herpetologist!
- Problems
  - Only 2 studies derive CRs (Barnett et al., 2009; Wood et al., 2009)
  - No media data (locate different sources)
  - Dry wt:fresh wt
  - Data reported for specific reptile tissues
  - LODs

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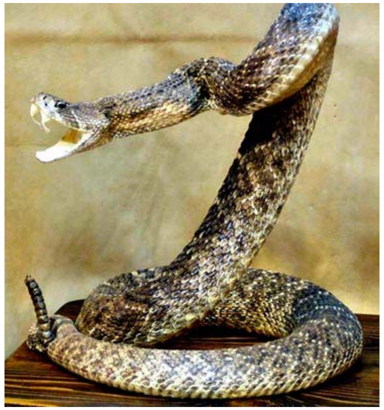
Dry weight:fresh weight conversion

Tissue	***n***	**dwt:fwt**	**Tissue**	***n***	**dwt:fwt**
Blood	1	0.21	Lung	12	0.27
Bone	3	0.71	Muscle	201	0.22
	59	0.24 (ash wt:fwt)	Scute	57	0.42
Brain	4	0.24	Spleen	1	0.25
Carcass	82	0.26	Whole-body	45	0.29
Kidney	138	0.28		3	0.07 (ash wt:fwt)
Liver	98	0.27	Egg	2	0.51



Converting tissue data to whole-body

$$C_{WB} = \frac{C_T \times FM_T}{B_T}$$

C_{WB} - whole-body activity concentration (Bq/kg fwt)

C_T - activity concentration of tissue T (Bq/kg fwt)

FM_T - fractional mass of tissue T relative to the whole-body

B_T - fraction of the total body burden of the radionuclide in tissue T

Need data on M_T and B_T - Major literature review required!

Institute for Sustainable Water
Integrated Management and
Ecosystem Research (SWIMMER)

UNIVERSITY OF LIVERPOOL

Fractional mass (FM_T)

Tissue (*T*)	**Generic reptile (animal)**	**Turtle (animal)**	**Tissue (*T*)**	**Generic reptile (egg)**
Bone	7.22E-02	4.20E-01	Albumin	2.48E-01
Kidney	3.00E-03	3.00E-03	Eggshell	1.22E-01
Liver	4.75E-02	5.80E-02	Yolk	6.31E-01
Muscle	8.77E-01	5.19E-01	Yolk-Albumin	8.78E-01

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Tissue conversions

- 30 elements

	Bone	Kidney	Liver	Muscle
Ag	1.04E+01	4.20E+00	4.92E-02	3.37E+01
Al	1.19E-01	4.31E+00	1.50E+00	2.43E+00
As	6.58E-01	6.68E-01	4.81E-01	1.11E+00
Ba	7.97E-02	6.41E+00	8.88E+00	9.95E+00
Ca	7.24E-02	1.86E+02	2.35E+02	2.74E+02
Ca	4.40E-01	3.68E+00	1.69E+01	1.23E+01
Co	1.77E+00	1.22E-02	1.16E-01	2.90E+00
Cr	5.08E-01	7.82E-01	9.63E-01	1.09E+00
Cs	3.53E+00	3.97E-01	1.27E+00	9.39E-01
Cu	7.34E-01	5.32E-01	6.00E-02	8.45E+00
Fe	2.72E+00	7.06E-01	7.85E-02	2.41E+00
Hg	7.96E-01	2.13E-01	1.86E-01	1.37E+00

Tissue conversions

- 30 elements

Non-turtle

Turtle

	Bone	Kidney	Liver	Muscle
Ag	1.04E+01	4.20E+00	4.92E-02	3.37E+01
Al	1.19E-01	4.31E+00	1.50E+00	2.43E+00
As	6.58E-01	6.68E-01	4.81E-01	1.11E+00
Ba	7.97E-02	6.41E+00	8.88E+00	9.95E+00
Ca	7.24E-02	1.86E+02	2.35E+02	2.74E+02
Ca	4.40E-01	3.68E+00	1.69E+01	1.23E+01
Co	1.77E+00	1.22E-02	1.16E-01	2.90E+00
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Fe	2.72E+00	7.06E-01	7.85E-02	2.41E+00
Hg	7.96E-01	2.13E-01	1.86E-01	1.37E+00

The CR database

- 251 data lines (856 measurements)
  - Snakes (13 species)
  - Lizards (16 species)
  - Turtles and tortoises (8 species)
  - Crocodilians (3 species)

- 35 elements in freshwater reptiles
  - Am, As, B, Ba, Ca, Cd, Ce, Cm, Co, Cr, Cs, Cu, Fe, Hg, K, La, Mg, Mn, Mo, Na, Ni, Pb, Po, Pu, Ra, Rb, Sb, Se, Sr, Th, U, V, Y, Zn, Zr

- 15 elements in terrestrial reptiles
  - Am, C, Cs, Cu, K, Mn, Ni, Pb, Po, Pu, Sr, Tc, Th, U, Zn

- 10 elements in freshwater reptile eggs
  - As, Cd, Cr, Cu, Fe, Hg, Mn, Pb, Zn

The CR database cont.

- Aquatic ecosystems
  - mainly United States and Canada
  - crocodilian mainly Australia & China
  - most data for snakes and turtles
  - no marine data

- Terrestrial ecosystems
  - Australia, Canada, Europe, Former Soviet Union & United States
  - mainly lizards and snakes

Sand dune vs non-sand dune

- CRs for small mammals shown to be 2 orders of magnitude lower than other terrestrial ecosystems (based on ERICA CRs – *Beresford et al., 2008*)

Organism	Am	Cs	Pu
Sand dune mammal	4.25E-04	2.16E-02	9.33E-04
Mammal	4.08E-02	2.87E+00	2.34E-02

Adapted from: *Wood et al. (2009) Radionuclide transfer to invertebrates and small mammals in a coastal sand dune ecosystem. Sci Total Environ*

Sand dune vs non-sand dune cont.

- Am
  - sand dune CR = 8.2×10^{-2}
  - Maralinga CR = 4.4×10^{-3}
  - Biophysical differences and/or source of Am

- Pu
  - sand dune CR = 1.3×10^{-2}
  - other terrestrial CR = 6.4×10^{-4}

- Actinides show opposite trend to mammals (reptile CRs higher at dunes)
  - Comparable or higher trophic levels than mammals
  - Food-chain differences?

- Cs CRs were comparable

Want to know more?

- Data feeding in to the Wildlife Transfer Handbook
- *Wood MD, Beresford NA, Semenov DV, Yankovich TL, Copplestone D (submitted) Radionuclide transfer to reptiles. Radiat Environ Biophys*

Acknowledgements

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Thanks and Goodbye!