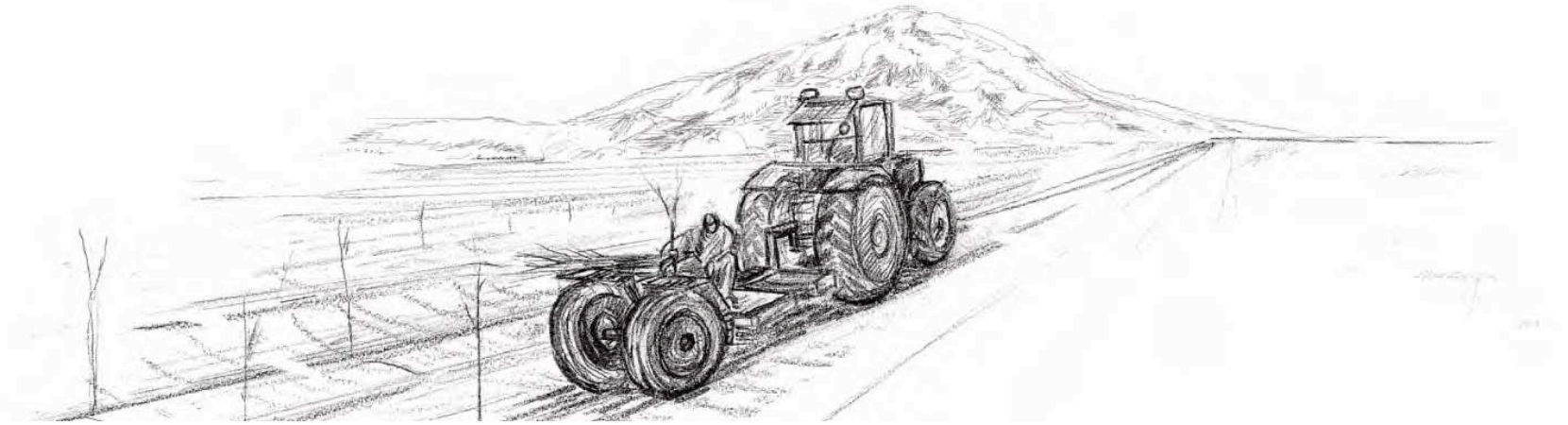
Measuring Pesticide Exposure

Novel Assessment Methods for Agricultural Producers, Workers and their Families



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- EPA/NIEHS Center for Child Health Risks Research
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Pesticide Exposure Assessment

- **Environmental Exposure Assessment**
  - Measure environmental concentrations
  - Characterize time-location and personal activities
  - Exposure and dose modeling
- **Biological Monitoring Approaches**
  - Pesticide metabolites in urine
  - Pesticides in body fluids (blood, saliva)
  - Biomarkers of effect (e.g., cholinesterase)

Biological Monitoring Studies

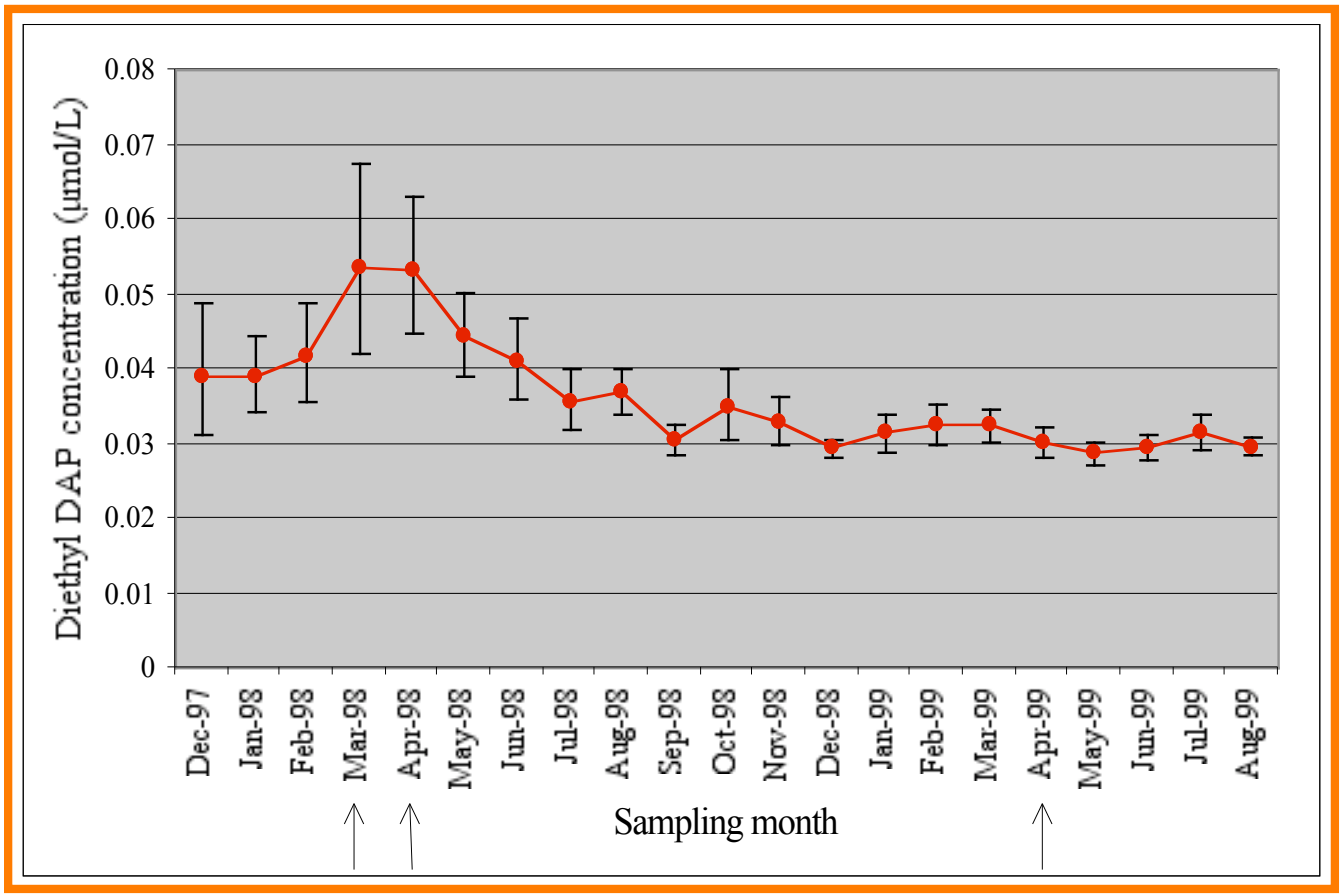
Longitudinal Biomonitoring Study in an Agricultural Community

Koch et al. Environ Health Perspect 110:829-33, 2002

- Agricultural community in E. Washington state
- OP pesticide exposure monitored in 44 preschool children for one year
- Spot urine samples collected on a bi-weekly basis
- Pesticide spray patterns documented by cooperative extension
- Para-occupational and proximity factors not significant predictors

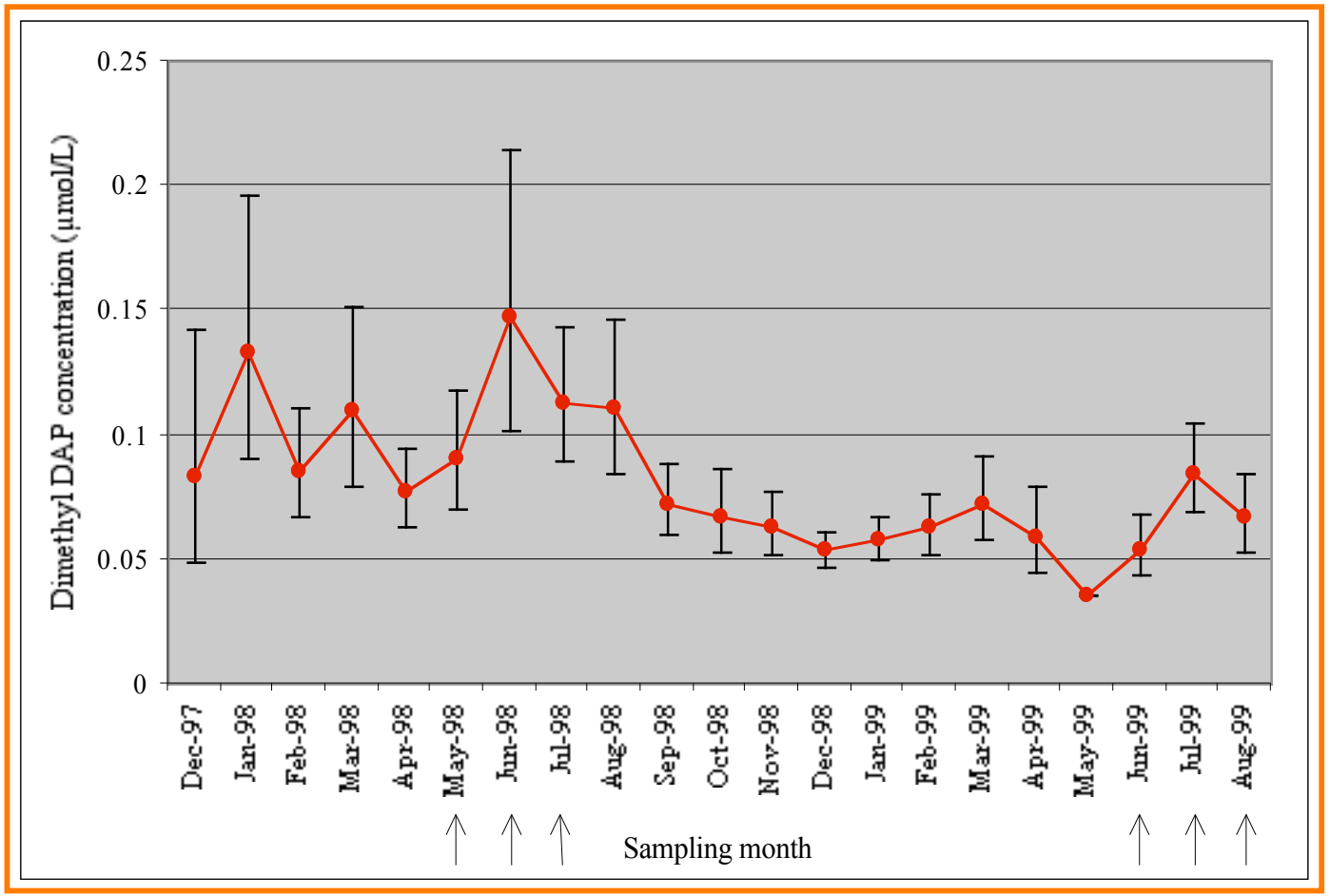
Geometric Means (μmol/L) and 95% C.I.for diethyl OP Pesticide Metabolite Concentrations by Sampling Months

(Arrows indicate months of OP pesticides spraying)



Geometric Means (μmol/L) and 95% C.I. for dimethyl OP Pesticide Metabolite Concentrations by Sampling Months

(Arrows indicate months of OP pesticides spraying)



Dietary Exposure to OP Pesticides

Curl et al., Environ Health Perspect 111:377-382 (2003)

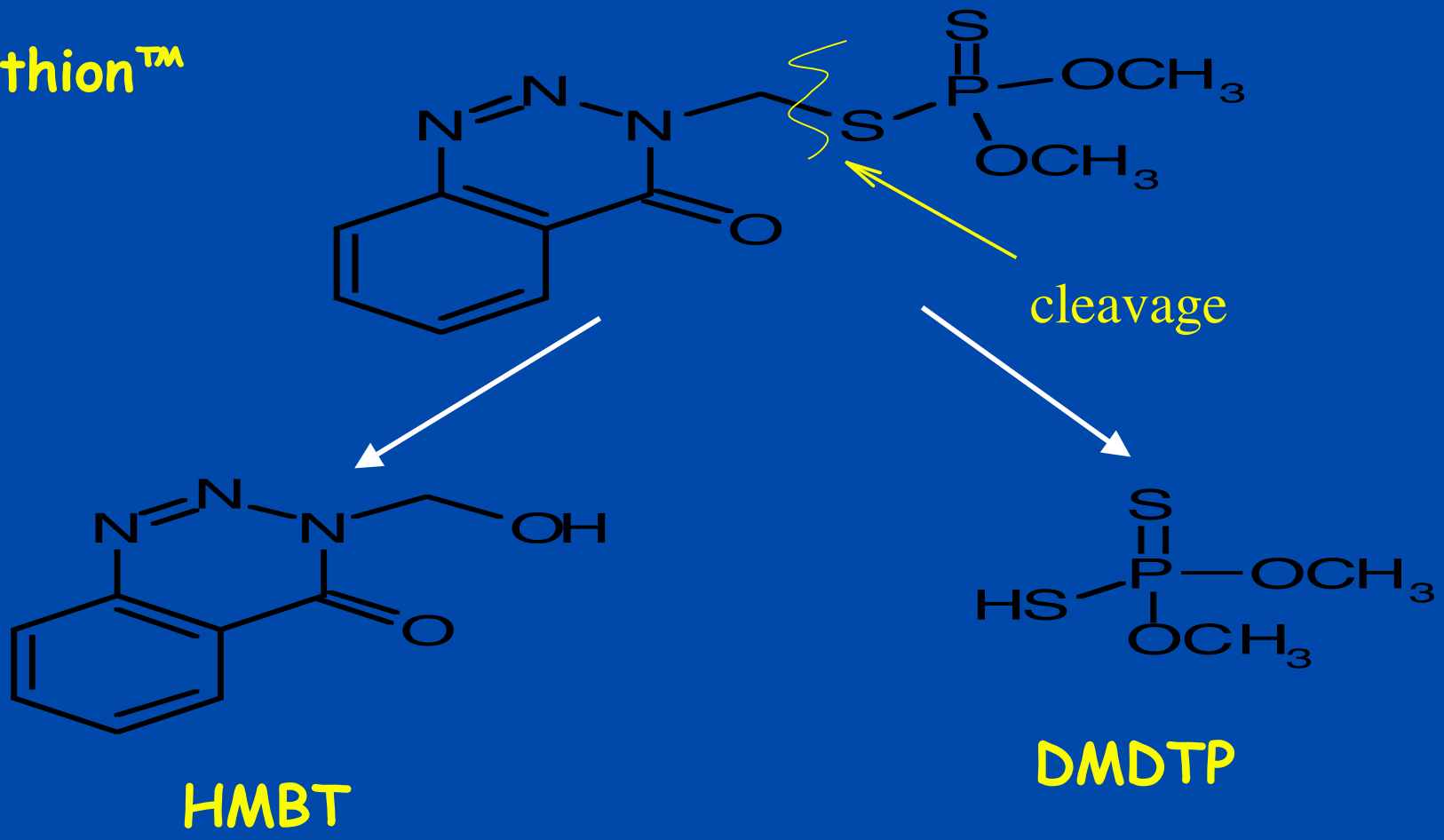
- Recruitment from two Seattle grocery stores
- 39 Pre-school children (2-5 yrs old)
- 3-day diet log kept by parents
- 24 hour urine sample
- Children classified by consumption of organic or conventional produce
- Residential pesticide use minimal

Dialkylphosphate Concentrations in Children's Urine Samples

	Median (μmol/L)	
	Dimethyl	Diethyl
Conventional	0.17	0.02
Organic	0.03	0.02

Dimethyl metabolites

Guthion™



HMBT

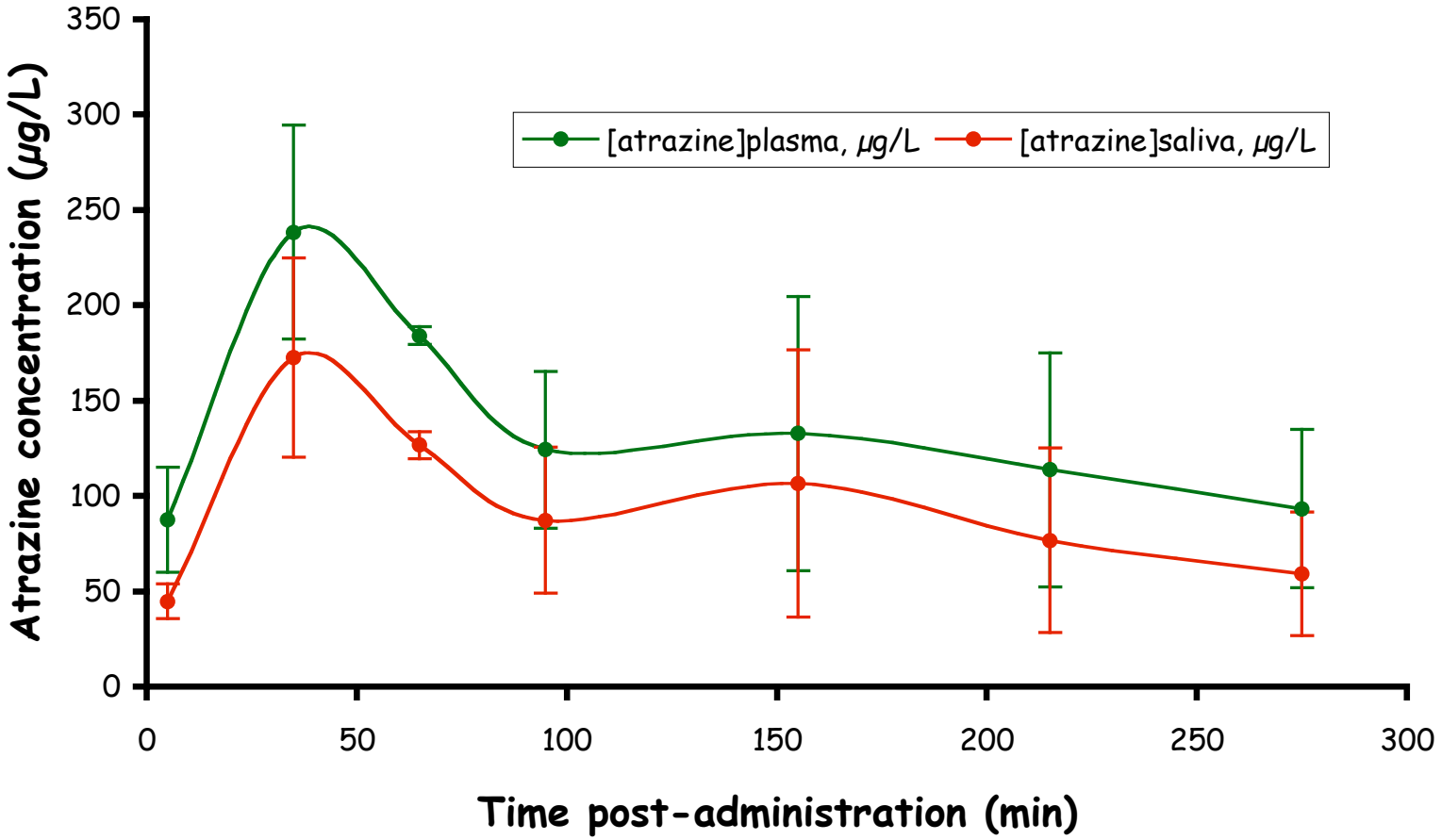
DMDTP

Saliva Studies in Animals

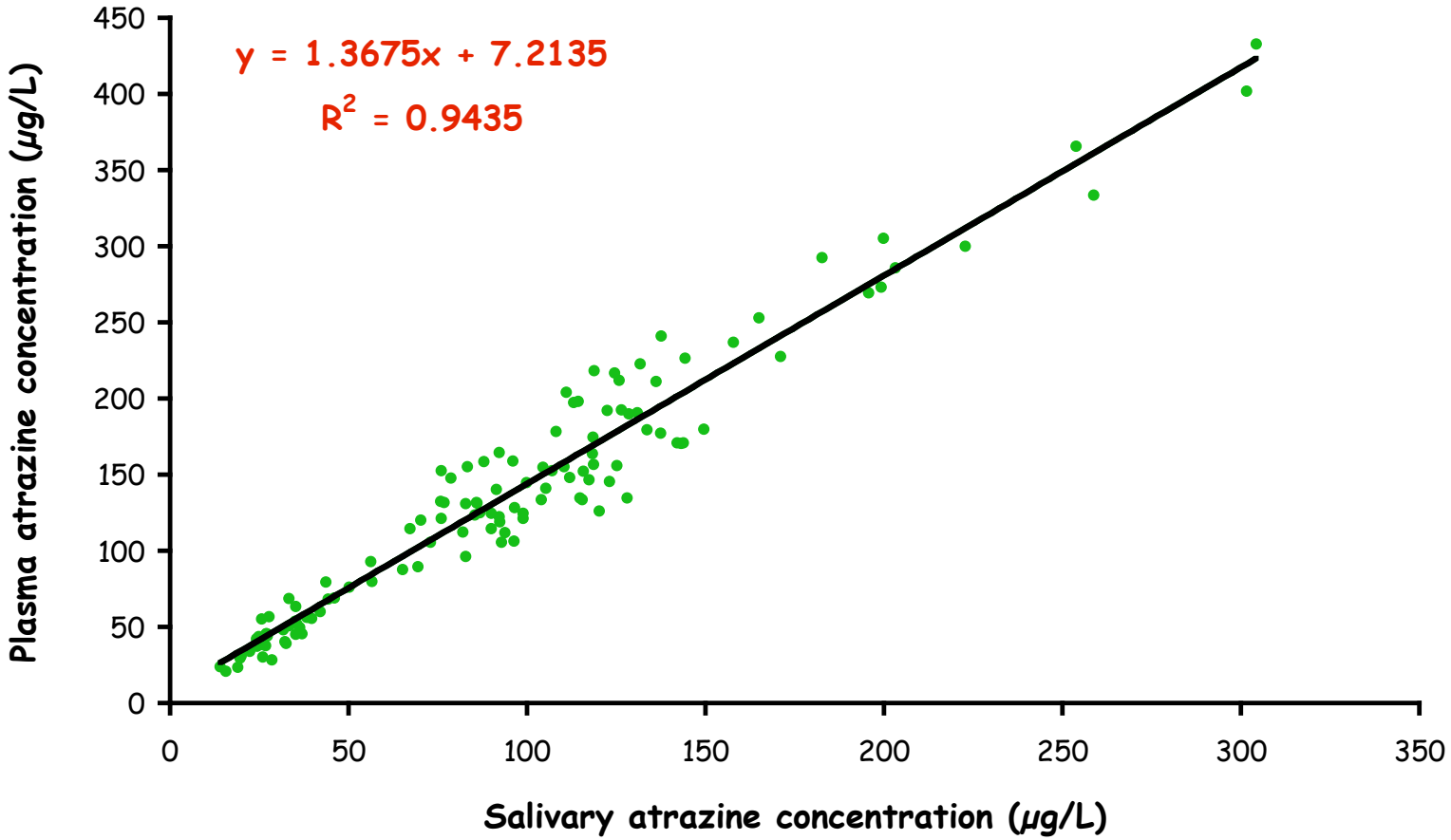
Lu et al., J Toxicol Environ Health 53:283-92 (1998)

- Intracellular passive diffusion determines appearance of pesticides in saliva
  - Lipid solubility
  - Degree of ionization (pKa)
  - Molecular weight
  - Protein binding
- Rodent selected as model animal
- Pesticide administration through i.v. injection, skin or gavage (oral) ingestion
- Simultaneous arterial blood and saliva collection

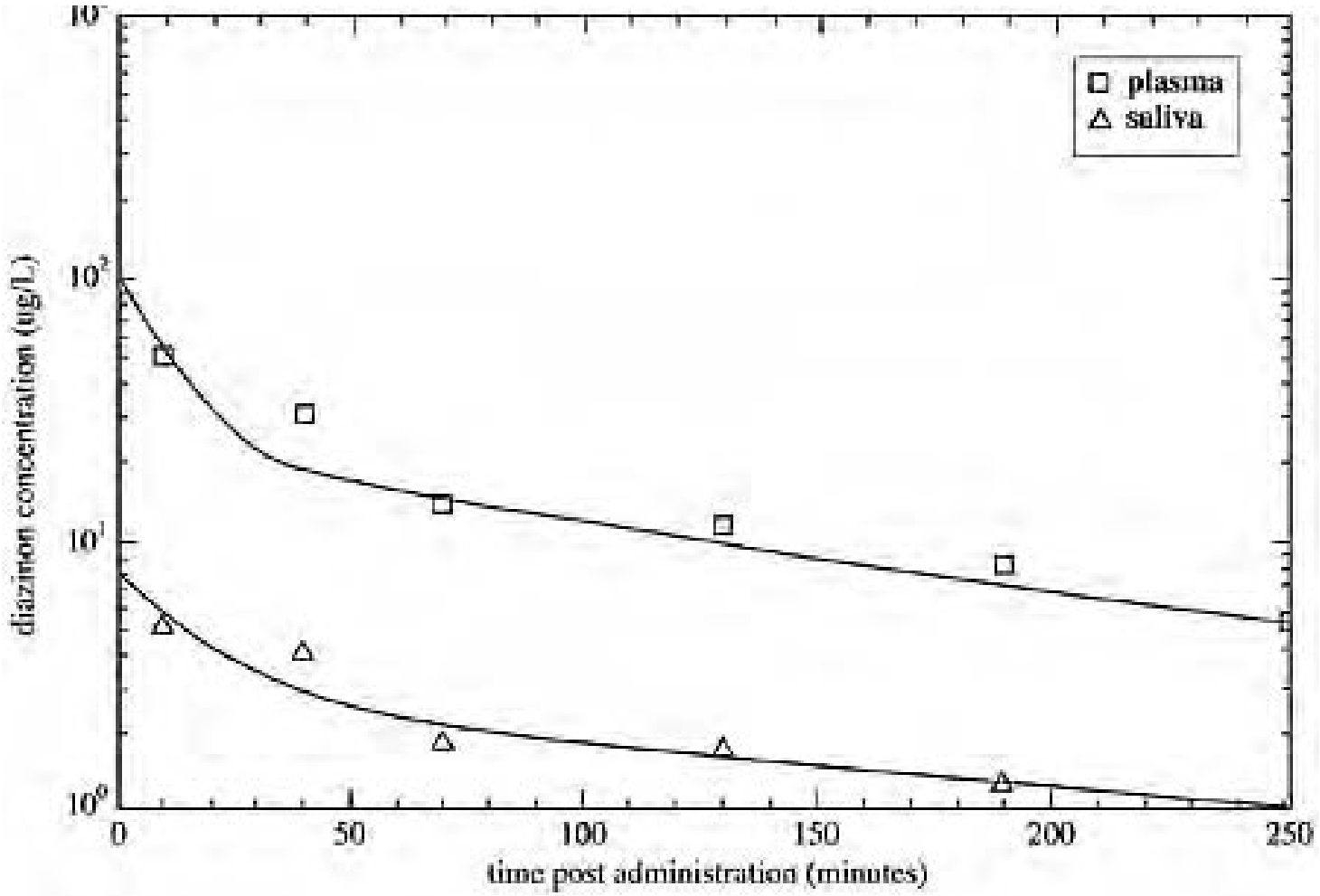
Concentration-time profiles of atrazine following gastric administration in rats



Regression model for saliva and plasma atrazine concentrations following i.v. and gastric administration in rats

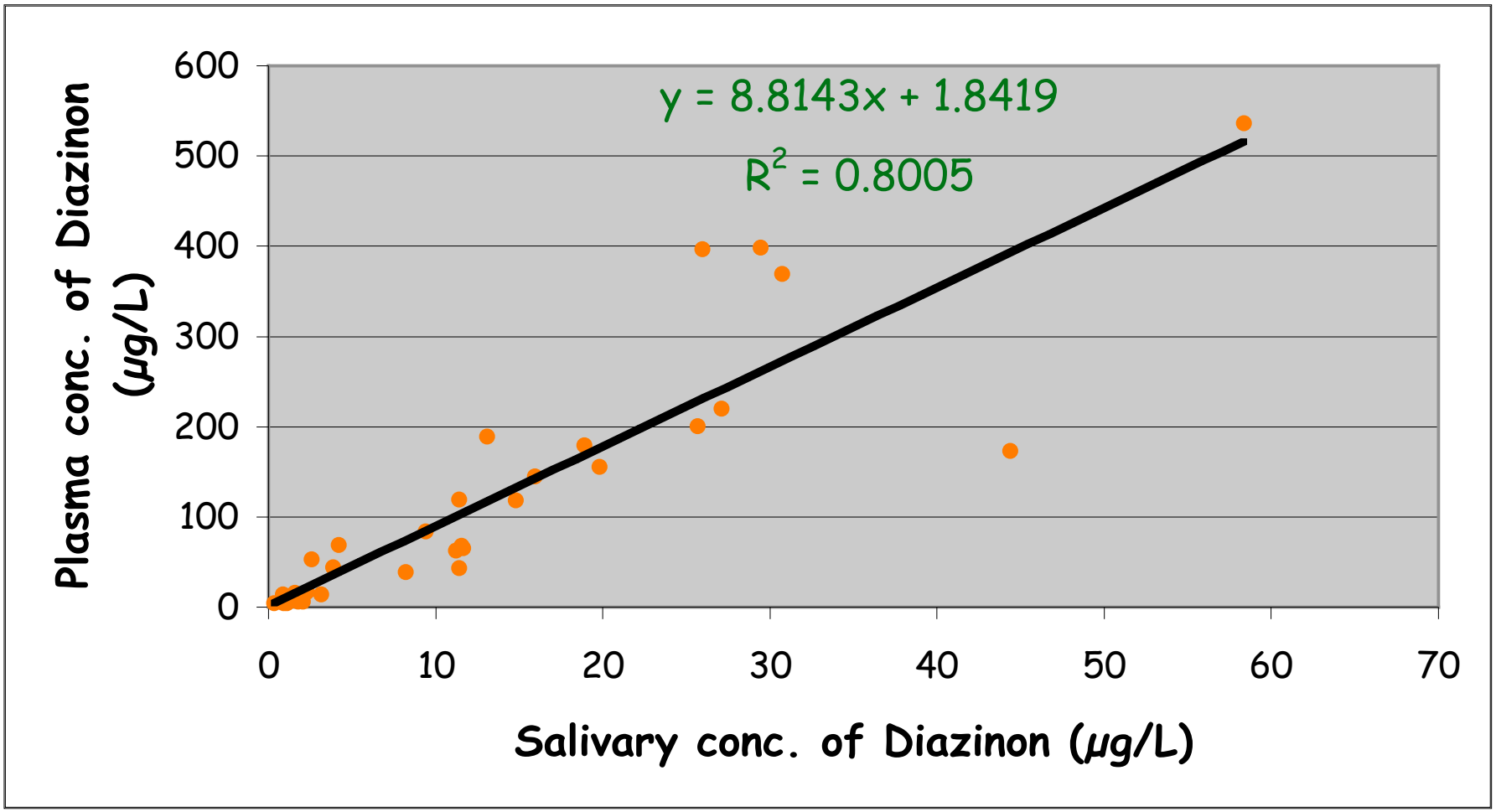


Observed and predicted saliva and plasma concentration-time profiles for diazinon in rats after I.V. bolus injection of 1 mg/kg diazinon



Solid line indicates the model fit using a two-compartment model

Correlation of salivary and plasma concentrations of diazinon following I.V. bolus injection in rats



Conclusions from Animal Studies

- Both atrazine and diazinon excreted into saliva,
- Salivary excretion of atrazine and diazinon unaffected by the dose, route of administration or salivary flow rate,
- Significant correlation of atrazine and diazinon concentration in saliva and plasma samples
- Findings suggest that salivary concentrations can be used to predict plasma levels for both pesticides.

Preliminary Survey of Atrazine Exposure Among Herbicide Applicators

in collaboration with the

National Institute for Occupational Safety and Health

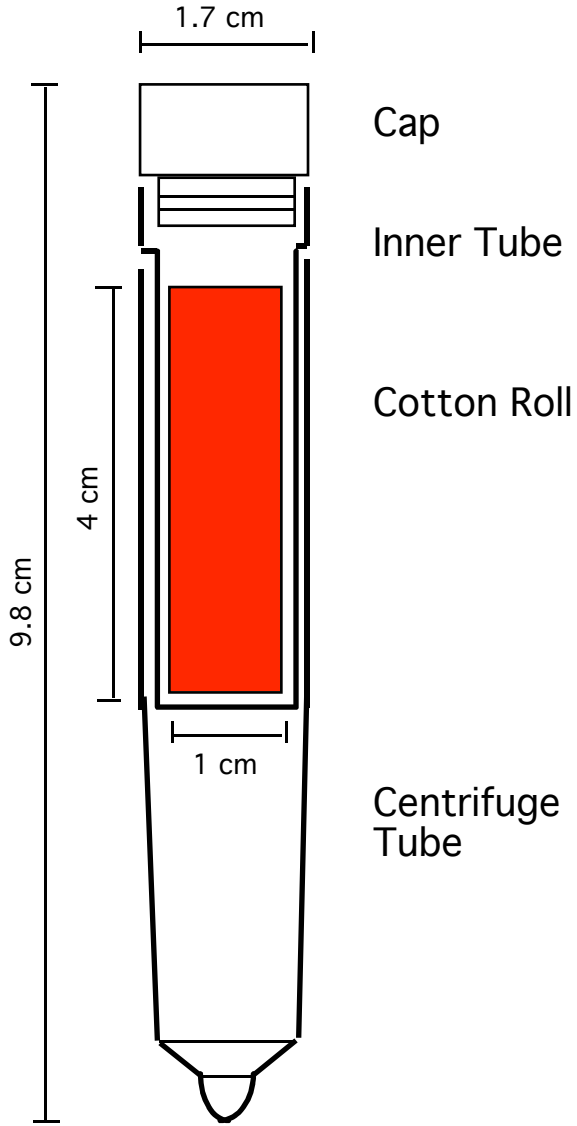
Denovan et al., Environ Health Perspect 73:457-462

- Evaluate sampling protocol for saliva collection in the field
- Measure atrazine concentrations in saliva for a cohort of herbicide applicators

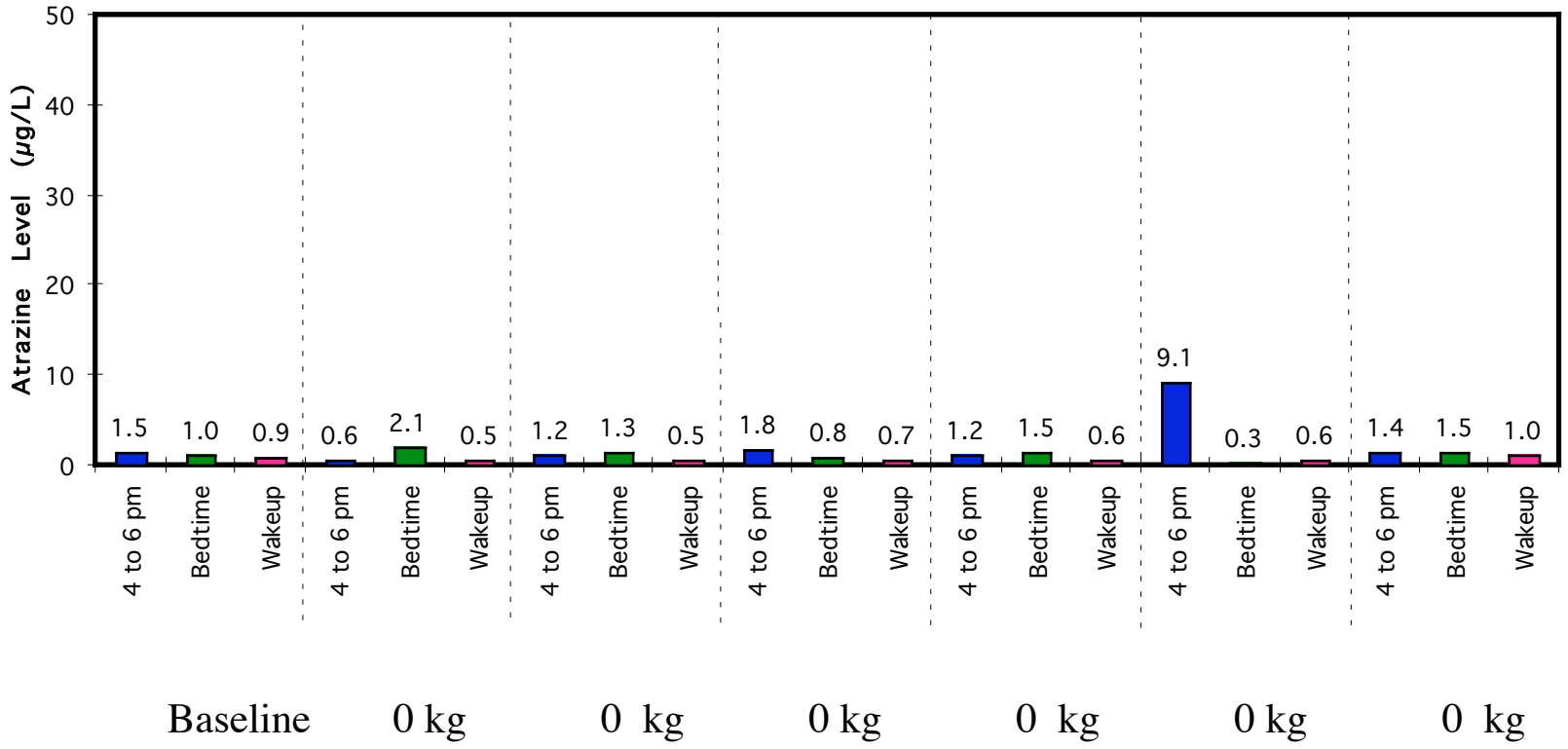
Study Design

- Baseline (3 months prior to application)
- 15 applicators
- Sampled every fourth day; 103 events
- Sampling schedule included post-shift, before bed, and next morning samples
- Urine, hand wash, skin patches collected by NIOSH

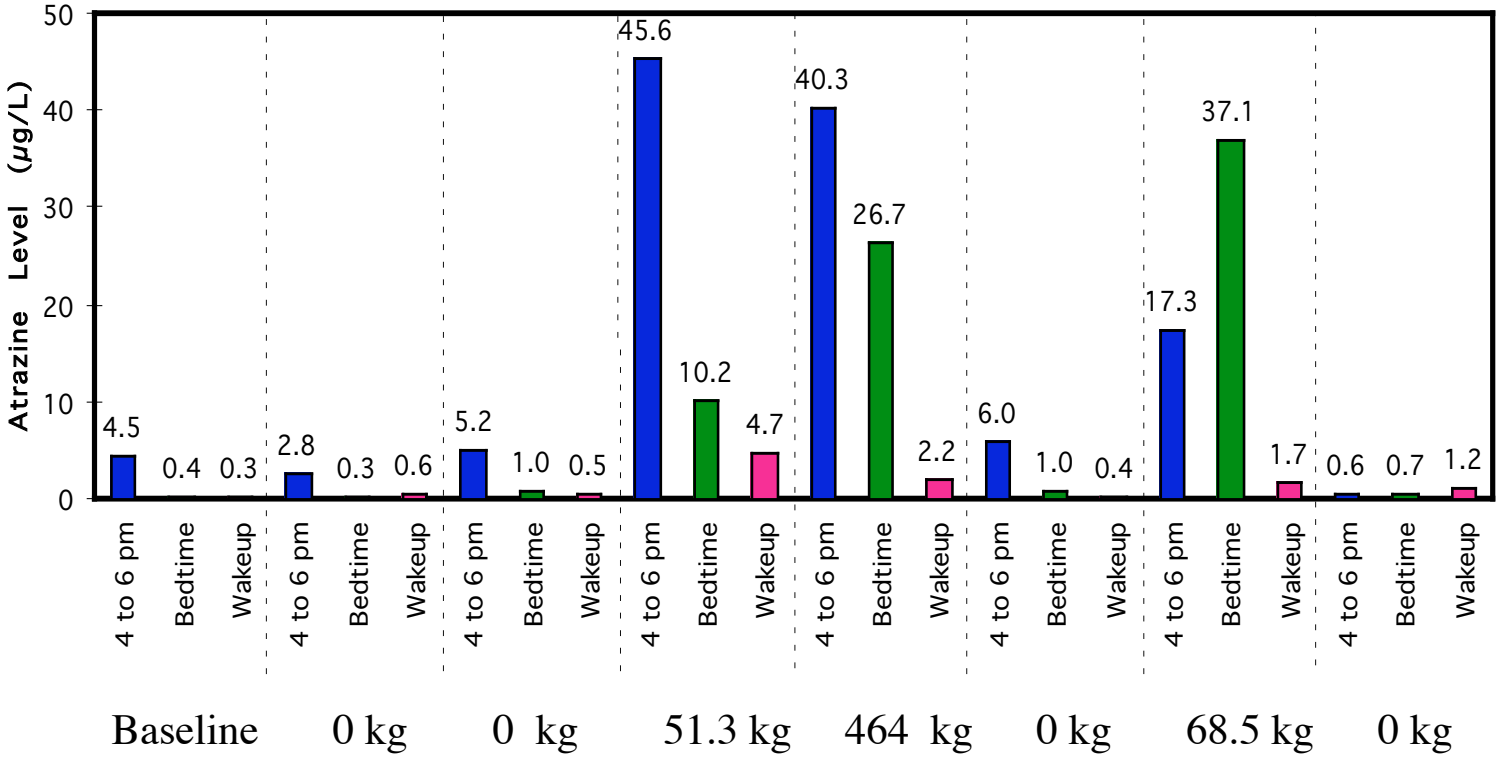
Salivette™


1.7 cm
Cap
Inner Tube
Cotton Roll
4 cm
9.8 cm
1 cm
Centrifuge
Tube

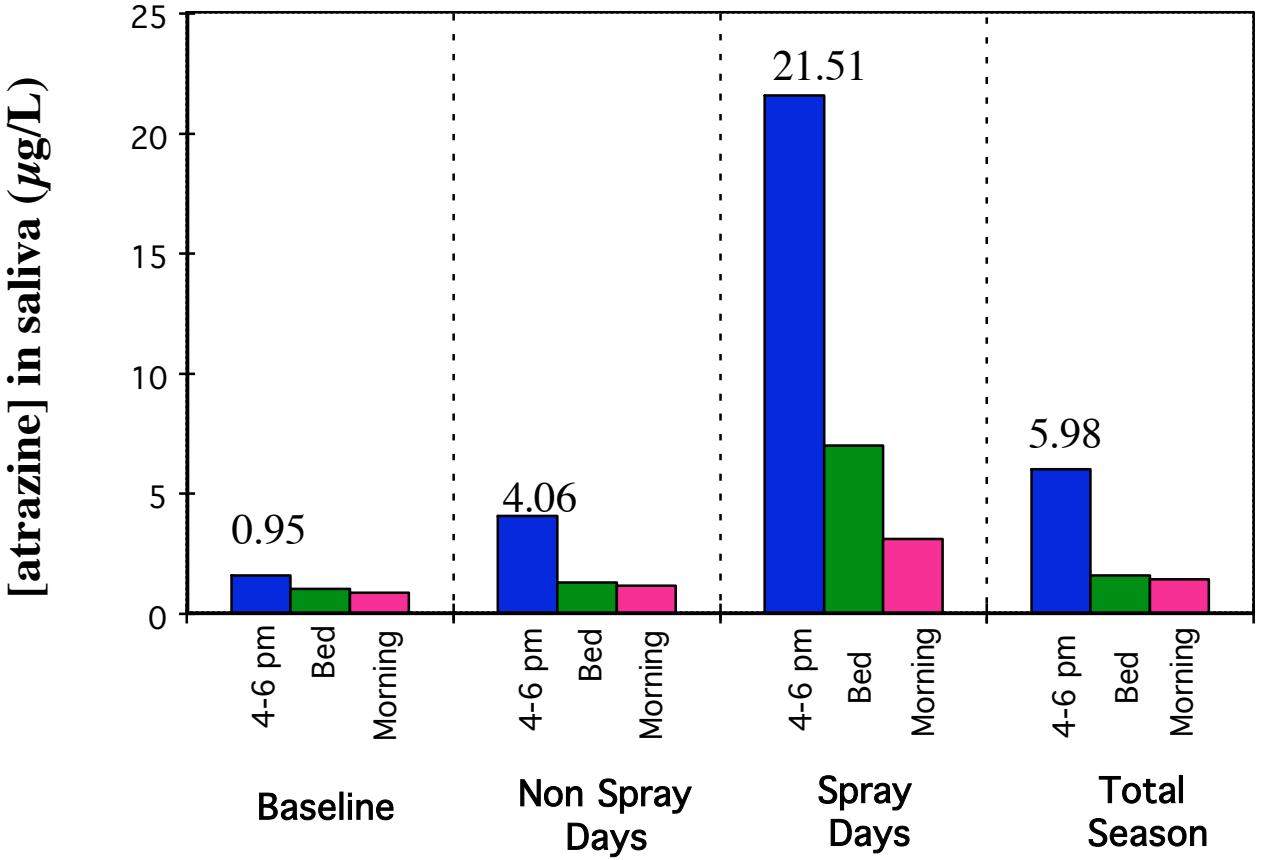
Worker #7


Atrazine Level (µg/L)
50
40
30
20
10
0
1.5
1.0
0.9
0.6
2.1
0.5
1.2
1.3
0.5
1.8
0.8
0.7
1.2
1.5
0.6
9.1
0.3
0.6
1.4
1.5
1.0
4 to 6 pm
Bedtime
Wakeup
Baseline
0 kg
0 kg
0 kg
0 kg
0 kg
0 kg

Worker #1


Atrazine Level (µg/L)
50
40
30
20
10
0
4.5
0.4
0.3
2.8
0.3
0.6
5.2
1.0
0.5
45.6
10.2
4.7
40.3
26.7
2.2
6.0
1.0
0.4
17.3
37.1
1.7
0.6
0.7
1.2
4 to 6 pm
Bedtime
Wakeup
Baseline
0 kg
0 kg
51.3 kg
464 kg
0 kg
68.5 kg
0 kg

Profiles of median salivary concentrations of atrazine for custom herbicide applicators



Conclusions from Field Study

- Saliva sampling is practical in the field
- Saliva captures the trends of atrazine exposure and elimination in the body
- Urine data confirmed the exposure even without atrazine spraying in the field
- Lack of plasma samples to confirm the validity of saliva biomonitoring

On-going Saliva Biomonitoring Studies

- Human exposure studies
  - Children's dietary study, Seattle
  - Farm worker family study, Nicaragua
  - Human controlled-exposure study (UC Davis)
- Explore other pesticides
  - Chlorpyrifos
  - Permethrin

Acknowledgments

- US EPA STAR Grant R828606

  2001 - 2004

- US EPA STAR Grant R829364

  2002 - 2006

- Dr. Dana Barr, CDC Laboratory

  National Center for Environmental Health

Environmental Monitoring Studies

Spray Drift Studies

- **Spray Drift Modeling Studies**
  - Human exposure not measured directly
- **Spray Drift Incident Studies**
  - Exposure estimated after-the-fact
- **Washington Aerial Spray Drift Study**
  - Measure and model spray event
  - Measure community and residential air and surface levels
  - Measure and model children's activities and exposures

Application Site

- **Central Washington State**
  - Dry summer climate
  - Flat topography
- **Aerial Applications on Potatoes**
  - 1-2 times per season every third season
  - Aerial applications -- fixed wing aircraft

Methamidophos

- Highly toxic organophosphorus insecticide (Toxicity I)
- Monitor-4™ 40% emulsifiable concentrate formulation
- 283 hectares treated @ 1.1 kg a.i. per hectare (1 lb/acre)

Study Site and Population

- **Agricultural Community**
  - Surrounded by potato, corn, wheat fields
  - Single-family residences, recreational facilities
- **Children**
  - Parents are farmworkers
  - Live in community year-round
  - Ages 3-11
  - 4 male, 4 female

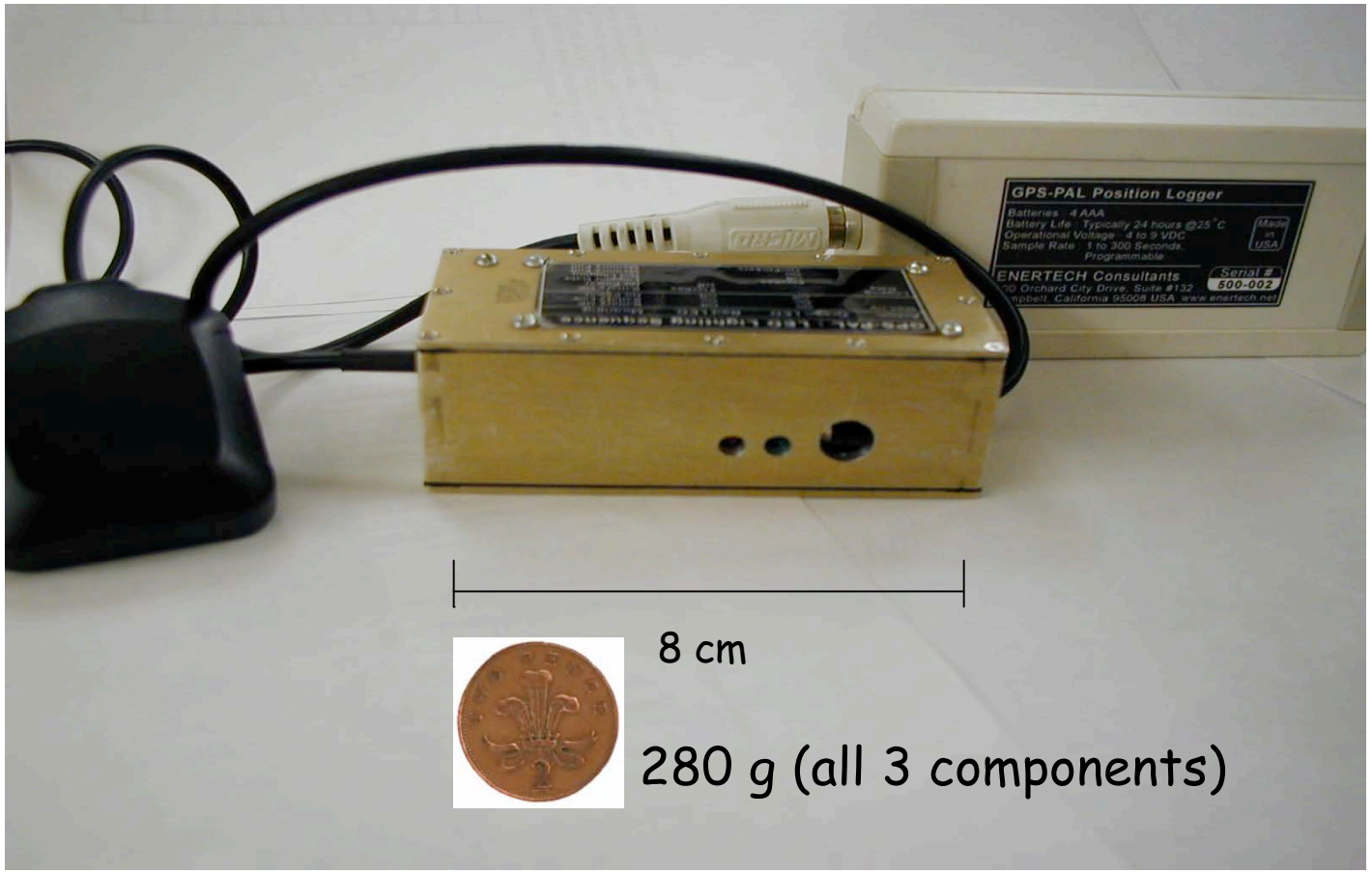
Informed consent/assent obtained from all parents and children

Recruitment Poster

Sampling Procedures

- **Deposition Samples**
  - Silica gel chromatography plates
- **Surface Wipes**
  - Playground equipment
  - Toys and apples
  - Indoor surfaces
- **Children's Hands**
  - Isopropanol wipes
- **Children's Activities**
  - Global positioning system - personal activity loggers
- **Air Samples, Housedust, Urine samples**

GPS Personal Acquisition Logger (GPS-PAL) (Entertech)



GPS-PALS Unit

Elgethun et al., Environ Health Perspect 111:115-122 (2003)

Clothing does not block reception

Key Findings

- **Well controlled aerial application**
  - Levels at field boundary 1,000X greater than off-target
- **Low levels on surfaces in community (Good News!)**
  - Measurable residues on play equipment and outdoor toys
  - No detectable residues on indoor surfaces
- **Children contact residues on spray and post-spray days**
  - Highest child hand exposure = 300 ng
  - Highest child cumulative exposure (2 days) = 790 ng
- **Child activities an important component of exposure analysis**
  - 8-fold difference between high and low child exposures

Work in Progress

- Develop dispersion models for vapors and particles
- Estimate dermal contact via deposition modeling and children's activities
- Estimate respiratory exposure via air modeling and children's activities
- Mass balance analysis of aggregate exposure and biological monitoring
- Risk analysis and communication to agricultural community