This report combines a series of statistical analyses done over the course of the investigation into inorganic arsenic in chicken livers:

- Statistical Analyses for Total Arsenic – pages 2 – 3;
- Statistical Analyses for Inorganic Arsenic – pages 4 – 14;
- Statistical Analyses for Non-inorganic Arsenic: DMA, MMA, 2-amino, N-acetyl, Roxarsone, Unknowns 3.5, 4.5, 5.5, 13, 21, 32 and 36 – pages 15 – 25.

[signature] Nov 4, 2010

Vicki Ann Lancaster, Ph.D.
Mathematical Statistician
Food and Drug Administration
Center for Veterinary Medicine
Office of New Animal Drug Evaluation
Division of Scientific Support
Mail Code: HFV – 160
Building: Metro Park North 2
Room: North 409
7500 Standish Place
Rockville, MD 20855

Phone: 240.276.8163
Fax: 240.276.8175

Project:	Inorganic Arsenic in Poultry
Scientist:	Joe Kawalek, Ph.D.
Subject:	Total As Analysis
Author:	Vicki Lancaster, Ph.D.
Date:	September 23, 2010

This report contains the descriptive statistics for the Total As ng/g wet wt.

Box plots are displayed separately for treated and control measurements due to the larges differences in the range for the two groups (see Figures 1 and 2, page 2). The box plots were constructed (estimates of the lower, middle and upper quartile) without taking into account the censored values (below the LOQ) and using the values as reported by the laboratory. The box plots are for visualization and not inferential purposes. To aid in interpretation, filled and unfilled symbols have been overlain on the box plots to identify the values above and below the LOQ(s). Descriptive statistics are displayed in Table 1, page 1. Due to censoring, descriptive statistics were estimated using the Kaplan-Meier estimator (Helsel, 2005 and Nelson, 1982).

An inferential test for location differences was conducted for withdrawal days 0 and 5 (due to the 100% censoring of the control measurements for withdrawal day 3, no inferential test was conducted). For withdrawal day 5 the nonparametric Wilcoxon Rank Sum test was used due to the larges differences in the variability of the treated and control measurements (the more common parametric t-test assume homogeneity of variances). The test provided a test statistic of W = 189 and a p-value = 2.086e-05. Based on the p-value, one would conclude the median of the total As concentrations for the treated group is larger than the median of the total As concentrations for the control group. For the comparison on withdrawal day 0, the Peto-Prentice was used to test for groups differences. This test was employed since it accommodates censored values. The test provided a test statistic of $\chi^2 = 15.1$ and a p-value = 1.04e-04. Based on the p-value, one would conclude the total As concentrations for the treated group are larger than the total As concentrations for the control group.

Table 1. Kaplan Meier Descriptive Statistics by Withdrawal Day for As (ng/g wet wt.)

Withdrawal Day	Group	N	Number / Percent Censored	Median	Mean	Standard Deviation
0	Control	8	4 / 50%	NA	3.9	0.9
	Treated	16	0 / 0%	2930	3113	1441
3	Control	8	8 / 100%	NA	NA	NA
	Treated	16	0 / 0%	1870	1890	1040
5	Control	9	0 / 0%	3.9	3.7	0.9
	Treated	21	0 / 0%	1096	1099	768

[1] NA = Not available, descriptive statistic cannot be estimated due to censoring.

Figure 1. Box Plots of Total As (ng/g wet wt.) for Treated Birds by Withdrawal Day
(Open Circles = Censored, Filled Circles = Uncensored)

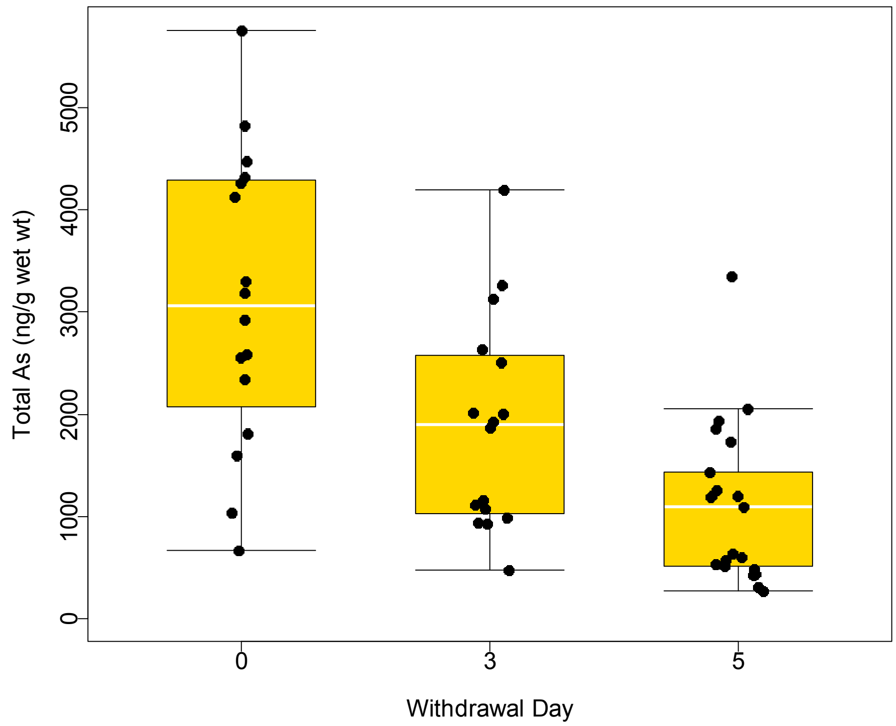
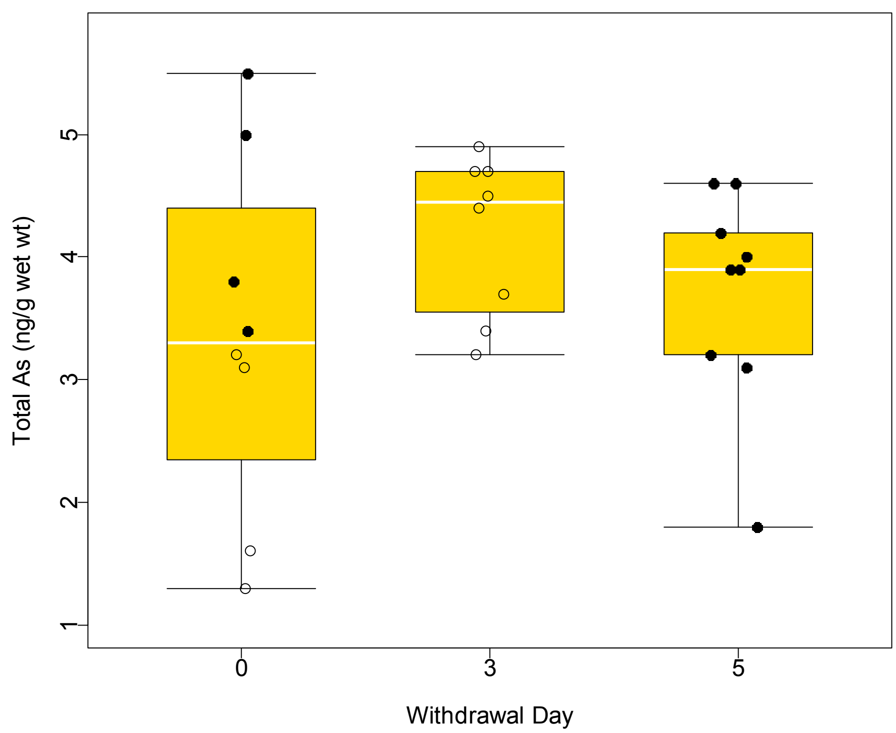


Figure 2. Box Plots of Total As (ng/g wet wt.) for Control Birds by Withdrawal Day
(Open Circles = Censored, Filled Circles = Uncensored)



Project:	Inorganic Arsenic in Poultry - iAsV
Scientists:	Mary Carson, Ph.D.
Subject:	Inorganic As Statistical Analyses
Author:	Vicki Lancaster, Ph.D.
Date:	September 28, 2010

Executive Summary

The data used in this report are inorganic arsenic concentrations (iAsV). The measurements were taken on the livers of chickens withdrawn from the target medication over a five day period; birds were sacrificed on Days 0, 3 and 5. When the iAsV concentrations were below the limit of quantification (LOQ = 0.6 or 2.0 ppb) the value was designated a censored value. When subtracting the method blank from the concentration resulted in a negative value, a zero concentration was substituted. Due to the high percentage of censored control measurements (100% for all three withdrawal days) the data are not appropriate for inferential mean comparisons between the treated and control birds nor can descriptive statistics such as means and variances be calculated for the control birds. Instead the Kaplan-Meier estimator, which takes into account censoring, was used to estimate the descriptive statistics of the treated birds and describe the trend in the mean concentration over the withdrawal time. On Day 0 the mean arsenic concentration in the treated chickens was 7.8 ppb with a 95% confidence interval of [4.7, 11.0], there was 2 censored values out of 16. The mean concentration dropped to 1.7 ppb [1.2, 2.2] on Day 3 with 11 censored values out of 16 and decreased slightly on Day 5 to 1.4 ppb [0.5, 2.3] with 12 censored values out of 21.

Data Description

The data were provided to Biostatistics Team 1 (HFV-163) by Mary Carson, Ph.D., from the Residue Division of Residue chemistry in the Office of Research (HFV-511). The data used in this analysis consisted of 80 measurements, 53 from the livers of treated birds and 27 from the livers of control birds. The measurements were taken over three withdrawal times, Day 0, 3 and 5. The livers were analyzed for inorganic arsenic (ppb), iAsIII and iAsV. Only the iAsV values were used in this report due to the lack of consensus regarding how to calculate a total arsenic concentration (the sum of iAsIII and iAsV) when one or both measurements were censored. All iAsIII measurements from control birds for all withdrawal days are less than the limit of quantification (LOQ) and all iAsIII measurements on treated birds for withdrawal Days 0 and 3 are less than the LOQ. Four treatment iAsIII measurements on Day 5 are above the LOQ. The data are displayed in Table 1 along with the LOQs, the LOQ is the same for both iAsIII and iAsV.

Non-inferential Comparisons

Statistical analyses were conducted using R 2.9.0 on the iAsV concentrations. Box plots of the iAsV concentrations are displayed for treated and control birds by withdrawal day in Figure 1. The box plots were constructed (estimates of the lower, middle and upper quartile) without taking into account the censored values (below the LOQ) and using the values as reported by the laboratory. The box plots are for visualization and not inferential purposes. To aid in interpretation, filled and unfilled symbols have been overlain on the box plots to identify the values above and below the LOQ(s). For all three withdrawal times the treated measurements are elevated compared to the control measurements. Figure 2 displays the similar box plots using the same range on the ordinate axis in order to evaluate the change in variability over withdrawal time (the inset plot displays control data only). The box plots show there is a decrease in variability for both the treated and control values from Day 0 to Day 3 and 5.

Due to censoring, descriptive statistics (Table 2) and confidence intervals (Table 3 and 4) for the treated birds were estimated using the Kaplan-Meier estimator (Helsel, 2005 and Nelson, 1982). No descriptive statistics for the control birds could be estimated due to the high level of censoring (100%).

Table 1. Inorganic Arsenic (ppb) Data in Chicken Liver over Withdrawal Days 0, 3 and 5

Treated Birds				Control Birds			
ID	**Day**	**LOQ**	**iAsV / iAsIII**	**ID**	**Day**	**LOQ**	**iAsV / iAsIII**
11	0	2.0	8.18 / 0.83	66	0	2.0	-0.39 / 0.00
12	0	2.0	21.53 / 0.27	69	0	2.0	0.05 / 0.00
21	0	2.0	18.19 / 0.53	75	0	2.0	1.10[1] / 0.00
26	0	2.0	19.35 / 0.45	77	0	2.0	-0.62 / 0.00
28	0	2.0	8.37 / 0.35	82	0	2.0	-0.91 / 0.00
36	0	2.0	3.75 / 0.42	84	0	2.0	0.49 / 0.00
40	0	2.0	0.13 / 0.07	97	0	2.0	-0.29 / 0.00
46	0	2.0	5.16 / 0.05	99	0	2.0	0.19 / 0.00
48	0	2.0	4.21 / 0.04				
52	0	2.0	5.39 / 1.18				
53	0	2.0	11.37 / 0.05				
54	0	2.0	3.97 / 0.32				
56	0	2.0	0.34 / 0.36				
58	0	2.0	2.25 / 0.49				
59	0	2.0	2.30 / 0.00				
60	0	2.0	6.83 / 1.56				
1	3	2.0	3.17 / 0.00	67	3	2.0	0.00 / 0.00
2	3	2.0	0.00 / 0.00	68	3	2.0	0.00 / 0.00
5	3	2.0	0.00 / 0.00	74	3	2.0	0.00 / 0.00
9	3	2.0	0.09 / 0.00	78	3	0.6	0.08 / 0.09
13	3	2.0	2.15 / 0.00	79	3	0.6	0.13 / 0.00
18	3	0.6	0.34 / 0.46	83	3	0.6	0.00 / 0.02
23	3	0.6	3.15 / 0.34	91	3	0.6	0.00 / 0.30
30	3	0.6	1.20 / 0.00	100	3	0.6	0.00 / 0.09
31	3	0.6	0.10 / 0.18				
33	3	0.6	0.28 / 0.24				
38	3	0.6	0.27 / 0.26				
47	3	0.6	0.33 / 0.48				
50	3	0.6	0.26 / 0.35				
61	3	0.6	0.52 / 0.51				
62	3	0.6	4.51 / 0.05				
65	3	0.6	0.47 / 0.53				
3	5	0.6	-0.19 / 0.62	70	5	0.6	-0.07 / 0.10
4	5	0.6	1.66 / 0.44	71	5	0.6	-0.50 / 0.31
6	5	0.6	0.47 / 0.00	72	5	0.6	-0.43 / 0.08
7	5	0.6	5.21 / 0.31	73	5	0.6	-0.46 / 0.02
8	5	0.6	0.03 / 0.55	81	5	0.6	-0.11 / 0.07
14	5	0.6	-0.03 / 0.08	86	5	0.6	-0.10 / 0.00
15	5	0.6	0.14 / 0.22	87	5	2.0	-0.60 / 0.00
16	5	0.6	-0.31 / 0.26	89	5	2.0	-0.10 / 0.00
19	5	0.6	0.26 / 0.11	92	5	0.6	-0.24 / 0.46
24	5	0.6	0.75 / 0.58	94	5	0.6	-0.20 / 0.30
27	5	2.0	9.05 / 0.00	98	5	0.6	-0.26 /0.28
29	5	0.6	0.31 / 0.19				
32	5	0.6	0.60 / 0.16				
37	5	0.6	0.86 / 0.28				
39	5	0.6	-0.10 / 0.06				
44	5	0.6	0.26 / 0.46				
49	5	0.6	-0.15 / 1.14				
54	5	0.6	0.86 / 0.45				
55	5	0.6	-0.09 / 0.63				
63	5	0.6	0.64 / 0.49				
64	5	0.6	1.04 / 0.75				

[1]Note: there is 1 Day 0 control value that would have been detected at the lower LOQ (0.6).

Table 2. Kaplan Meier Descriptive Statistics by Withdrawal Day

Withdrawal Day	Group	N	Number / Percent Censored	Median	Mean	Standard Deviation
0	Control	8	8 / (100.00%)	NA[1]	NA	NA
	Treated	16	2 / (12.50%)	5.2	7.8	6.5
3	Control	8	8 / (100.00%)	NA	NA	NA
	Treated	16	11 / (68.75%)	NA	1.7	1.1
5	Control	11	11 / (100.00%)	NA	NA	NA
	Treated	21	12 / (57.14%)	NA	1.4	2.1

[1] NA = Not available, descriptive statistic cannot be estimated due to censoring.

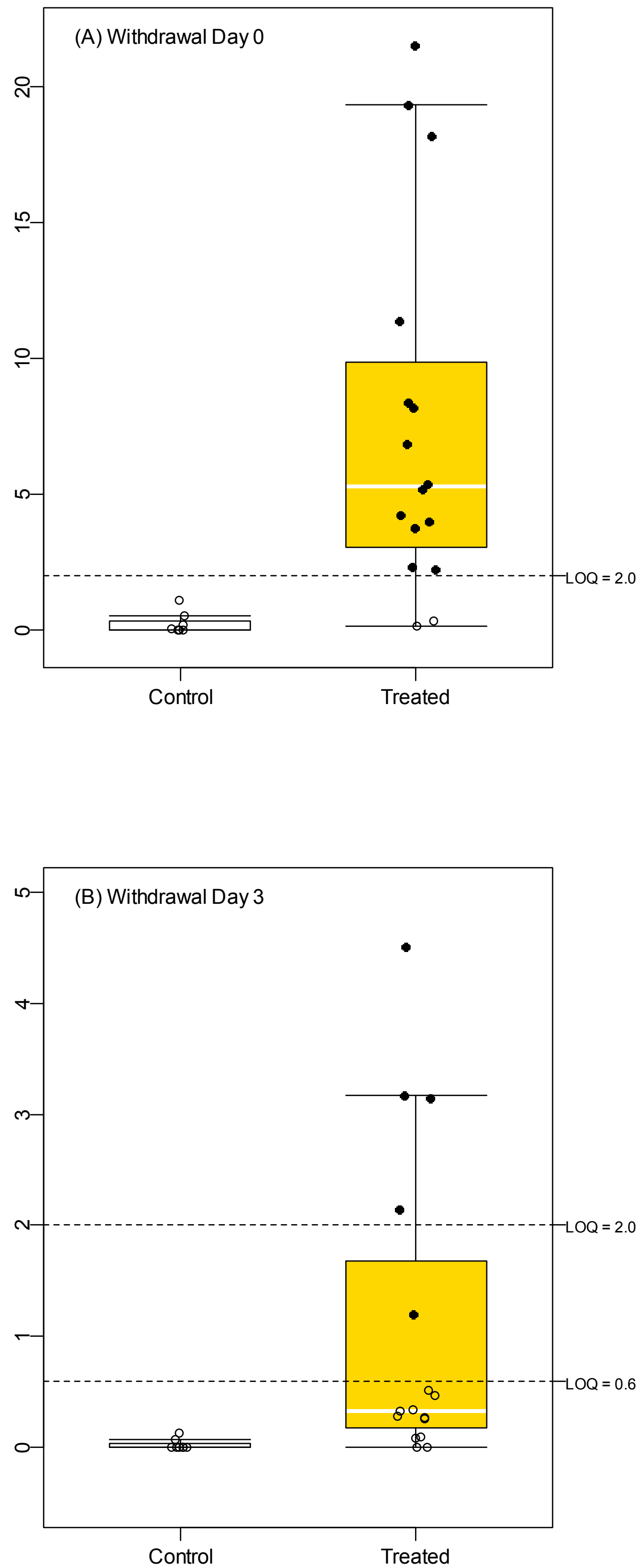
Table 3. 95% Confidence Limits for the Treated Means by Withdrawal Day

Withdrawal Day	Group	N	Number / Percent Censored	Mean	Lower CL	Upper CL
0	Treated	16	2 / (12.50%)	7.8	4.7	11.0
3	Treated	16	11 / (68.75%)	1.7	1.2	2.2
5	Treated	21	12 / (57.14%)	1.4	0.5	2.3

Table 4. 90% Confidence Limits for the Treated Means by Withdrawal Day

Withdrawal Day	Group	N	Number / Percent Censored	Mean	Lower CL	Upper CL
0	Treated	16	2 / (12.50%)	7.8	5.2	10.5
3	Treated	16	11 / (68.75%)	1.7	1.3	2.2
5	Treated	21	12 / (57.14%)	1.4	0.6	2.1

Figure 1. Box Plots of Inorganic Arsenic (ppb) for Treated and Control Birds
Open Circles = Censored, Filled Circles = Uncensored; Dotted horizontal line is at the limit of quantification
(Note: ordinate axes are different for each plot.)



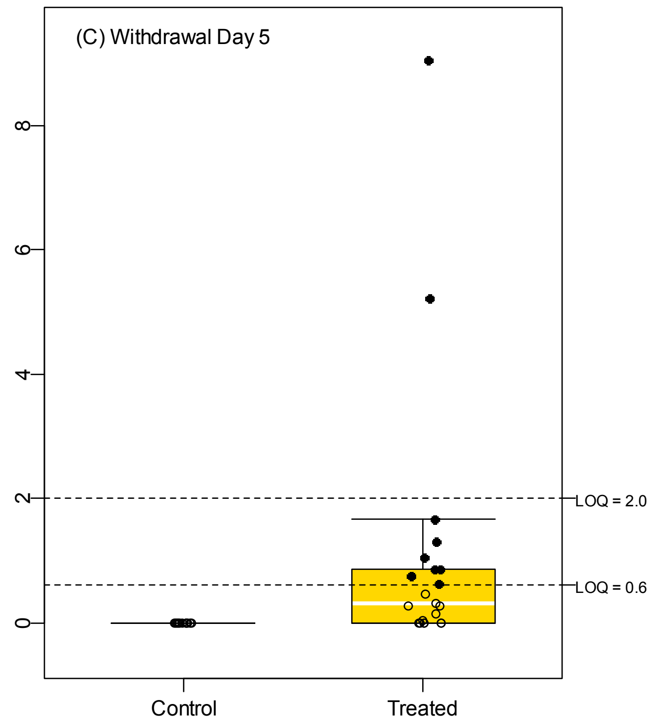
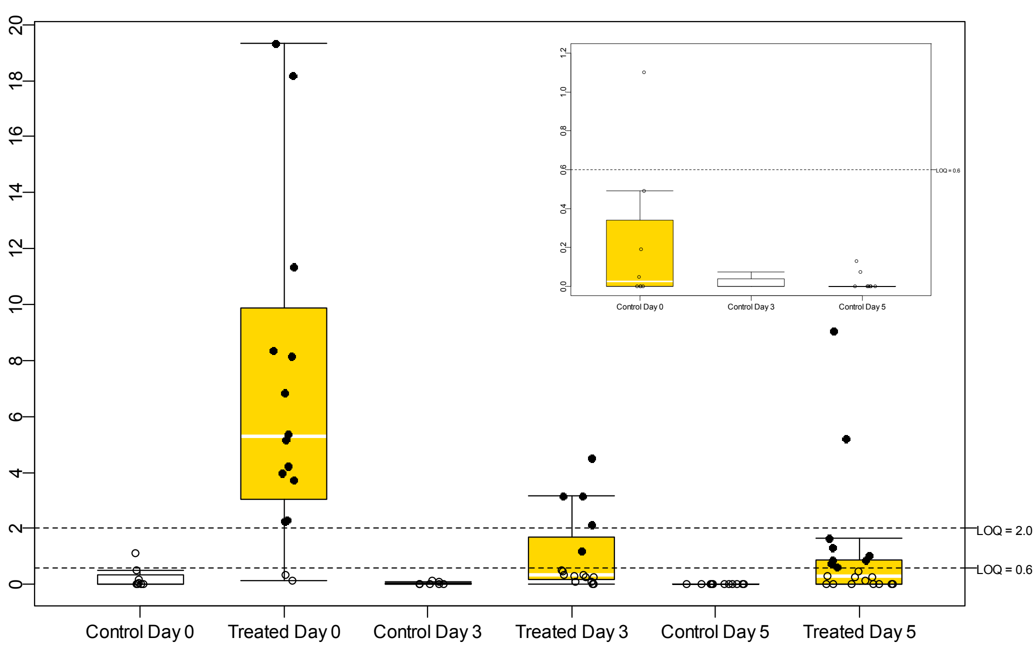


Figure 2. Box Plots of Inorganic Arsenic (ppb) for Treated and Control Birds
Open Circles = Censored, Filled Circles = Uncensored; Dotted horizontal line is at the limit of quantification



References

Helsel, Dennis R. (2005). Nondetects and Data Analysis: Statistics for censored environmental data. John Wiley & Sons, Inc., USA.

Nelson, Wayne (1982). Applied Life Data Analysis. John Wiley & Sons, Inc., USA.

R Development Core Team, R: A Language and Environment for Statistical Computing, R Foundation for Statistical Computing, Vienna, Austria, 2008 http://www.R-project.org

Appendix

How to Interpret a Box plot:

A ***box plot*** is a rectangle, the top and bottom of the rectangle are located at the upper and lower quartiles of the data; the horizontal white line within the rectangle is located at the median. Lines in the shape of a "T" extend from the box to the nearest value not beyond the ***standard span*** from the quartiles. These lines are often referred to as whiskers. Values beyond the end of the whiskers are drawn individually as filled circles. Box plots that are symmetric indicate a bell-shaped distribution.

The ***standard span*** is 1.5 times the ***inter-quartile range*** (IQR).

The ***quantile*** of the data is a number that divides the data into two groups, so that a fraction of the observations fall below the quantile and a fraction lie above the quantile. For example, the 75^{th} quantile (Q(.75)) divides the data set such the three fourths of the observations fall below Q(.75) and one fourth lie above.

- The ***median*** is the 50^{th} quantile, Q(.50).
- The ***upper quartile*** is the 75^{th} quantile, Q(.75).
- The ***lower quartile*** is the 25^{th} quantile, Q(.25).
- The ***IQR*** = Q(.75) – Q(.25).

R Code

```
data$As<-ifelse(data$As < 0, 0, data$As)
Data0<- data[data$Day==0,]
Data3<- data[data$Day==3,]
Data5<- data[data$Day==5,]

#Figure 1 (A)
par(pty="m", mar=c(2,5,2,5),mgp=c(3,.5,0))
splus <- list(boxwex=0.6, staplewex=1, boxfill="gold",
          medlwd=3, medcol="white", whisklty=1, outpch=16)
boxplot(Data0$As~Data0$Type, axes=TRUE, ylim=c(-0.5, 22), pars=splus, outline=FALSE)
abline(h=2, lty=8)
axis(side=4, at=2, label="LOQ = 2.0", cex=0.25, cex.axis=0.75, las=1)
points(jitter(rep(2, length(Data0$As[Data0$Censored=="FALSE"&Data0$Type=="Treated"])), 2),
        Data0$As[Data0$Censored=="FALSE"&Data0$Type=="Treated"], pch=16)
points(jitter(rep(2, length(Data0$As[Data0$Censored=="TRUE"&Data0$Type=="Treated"])), 2),
        Data0$As[Data0$Censored=="TRUE"&Data0$Type=="Treated"], pch=1)
points(jitter(rep(1, length(Data0$As[Data0$Censored=="FALSE"&Data0$Type=="Control"])), 2),
        Data0$As[Data0$Censored=="FALSE"&Data0$Type=="Control"], pch=16)
points(jitter(rep(1, length(Data0$As[Data0$Censored=="TRUE"&Data0$Type=="Control"])), 2),
        Data0$As[Data0$Censored=="TRUE"&Data0$Type=="Control"], pch=1)
mtext(side=3, "(A) Withdrawal Day 0", adj=0.1, line=-1.5)

#Figure 1 (B)
boxplot(Data3$As~Data3$Type, ylim=c(-0.5, 5), axes=TRUE, pars=splus, outline=FALSE)
abline(h=2.0, lty=8)
abline(h=0.6, lty=8)
axis(side=4, at=2.0, label="LOQ = 2.0", cex.axis=0.75, las=1)
axis(side=4, at=0.6, label="LOQ = 0.6", cex.axis=0.75, las=1)
points(jitter(rep(2, length(Data3$As[Data3$Censored=="FALSE"&Data3$Type=="Treated"])), 2),
        Data3$As[Data3$Censored=="FALSE"&Data3$Type=="Treated"], pch=16)
points(jitter(rep(2, length(Data3$As[Data3$Censored=="TRUE"&Data3$Type=="Treated"])), 2),
        Data3$As[Data3$Censored=="TRUE"&Data3$Type=="Treated"], pch=1)
```

```
points(jitter(rep(1, length(Data3$As[Data3$Censored=="FALSE"&Data3$Type=="Control"])), 2),
        Data3$As[Data3$Censored=="FALSE"&Data3$Type=="Control"], pch=16)
points(jitter(rep(1, length(Data3$As[Data3$Censored=="TRUE"&Data3$Type=="Control"])), 2),
        Data3$As[Data3$Censored=="TRUE"&Data3$Type=="Control"], pch=1)
mtext(side=3, "(B) Withdrawal Day 3", adj=0.1, line=-1.5)

#Figure 1 (C)
boxplot(Data5$As~Data5$Type, ylim=c(-0.5, 9.5), axes=TRUE, pars=splus, outline=FALSE)
abline(h=2.0, lty=8)
abline(h=0.6, lty=8)
axis(side=4, at=2.0, label="LOQ = 2.0", cex.axis=0.75, las=1)
axis(side=4, at=0.6, label="LOQ = 0.6", cex.axis=0.75, las=1)
points(jitter(rep(2, length(Data5$As[Data5$Censored=="FALSE"&Data5$Type=="Treated"])), 2),
        Data5$As[Data5$Censored=="FALSE"&Data5$Type=="Treated"], pch=16)
points(jitter(rep(2, length(Data5$As[Data5$Censored=="TRUE"&Data5$Type=="Treated"])), 2),
        Data5$As[Data5$Censored=="TRUE"&Data5$Type=="Treated"], pch=1)
points(jitter(rep(1, length(Data5$As[Data5$Censored=="FALSE"&Data5$Type=="Control"])), 2),
        Data5$As[Data5$Censored=="FALSE"&Data5$Type=="Control"], pch=16)
points(jitter(rep(1, length(Data5$As[Data5$Censored=="TRUE"&Data5$Type=="Control"])), 2),
        Data5$As[Data5$Censored=="TRUE"&Data5$Type=="Control"], pch=1)
mtext(side=3, "(C) Withdrawal Day 5", adj=0.1, line=-1.5)

CAs0<-Data0$As[Data0$Type=="Control"]
CAs0cen<-Data0$Censored[Data0$Type=="Control"]
TAs0<-Data0$As[Data0$Type=="Treated"]
TAs0cen<-Data0$Censored[Data0$Type=="Treated"]
As0<-c(CAs0, TAs0)
As0cen<-c(CAs0cen, TAs0cen)
As0group<-rep(c("Control", "Treated"), c(length(CAs0), length(TAs0)))
censummary(CAs0, CAs0cen)
censummary(TAs0, TAs0cen)

CAs3<-Data3$As[Data3$Type=="Control"]
CAs3cen<-Data3$Censored[Data3$Type=="Control"]
TAs3<-Data3$As[Data3$Type=="Treated"]
TAs3cen<-Data3$Censored[Data3$Type=="Treated"]
As3<-c(CAs3, TAs3)
As3cen<-c(CAs3cen, TAs3cen)
As3group<-rep(c("Control", "Treated"), c(length(CAs3), length(TAs3)))
censummary(CAs3, CAs3cen)
censummary(TAs3, TAs3cen)

CAs5<-Data5$As[Data5$Type=="Control"]
CAs5cen<-Data5$Censored[Data5$Type=="Control"]
TAs5<-Data5$As[Data5$Type=="Treated"]
TAs5cen<-Data5$Censored[Data5$Type=="Treated"]
As5<-c(CAs5, TAs5)
As5cen<-c(CAs5cen, TAs5cen)
As5group<-rep(c("Control", "Treated"), c(length(CAs5), length(TAs5)))
censummary(CAs5, CAs5cen)
censummary(TAs5, TAs5cen)

# Create a Kaplan-Meier ECDF, plot and descriptive statistics
cenfitAs0<-cenfit(TAs0, TAs0cen)
plot(cenfitAs0)
summary(cenfitAs0)
median(cenfitAs0)
mean(cenfitAs0)
sd(cenfitAs0)
```

```
cenfitAs3<-cenfit(TAs3, TAs3cen)
plot(cenfitAs3)
summary(cenfitAs3)
median(cenfitAs3)
mean(cenfitAs3)
sd(cenfitAs3)

cenfitAs5<-cenfit(TAs5, TAs5cen)
plot(cenfitAs5)
summary(cenfitAs5)
median(cenfitAs5)
mean(cenfitAs5)
sd(cenfitAs5)

#Figure 2
win.graph(height=7, width=12)
par(pty="m", mar=c(2,5,2,5), mgp=c(3,.5,0))
boxplot(CAs0, TAs0, CAs3, TAs3, CAs5, TAs5, axes=FALSE, pars=splus, outline=FALSE)
abline(h=0.6, lty=8)
abline(h=2.0, lty=8)
axis(side=2, at=seq(from=0, to=24, by=2))
axis(side=1, at=c(1, 2, 3, 4, 5, 6), labels=c("Control Day 0","Treated Day 0",
          "Control Day 3","Treated Day 3","Control Day 5","Treated Day 5"))
axis(side=4, at=2.0, label="LOQ = 2.0", cex.axis=0.65, las=1)
axis(side=4, at=0.6, label="LOQ = 0.6", cex.axis=0.65, las=1)
points(jitter(rep(1, length(CAs0[CAs0cen=="TRUE"])), 2),
                CAs0[CAs0cen=="TRUE"], pch=1)
points(jitter(rep(1, length(CAs0[CAs0cen=="FALSE"])), 2),
                CAs0[CAs0cen=="FALSE"], pch=16)
points(jitter(rep(2, length(TAs0[TAs0cen=="TRUE"])), 2),
                TAs0[TAs0cen=="TRUE"], pch=1)
points(jitter(rep(2, length(TAs0[TAs0cen=="FALSE"])), 2),
                TAs0[TAs0cen=="FALSE"], pch=16)
points(jitter(rep(3, length(CAs3[CAs3cen=="TRUE"])), 2),
                CAs3[CAs3cen=="TRUE"], pch=1)
points(jitter(rep(3, length(CAs3[CAs3cen=="FALSE"])), 2),
                CAs3[CAs3cen=="FALSE"], pch=16)
points(jitter(rep(4, length(TAs3[TAs3cen=="TRUE"])), 2),
                TAs3[TAs3cen=="TRUE"], pch=1)
points(jitter(rep(4, length(TAs3[TAs3cen=="FALSE"])), 2),
                TAs3[TAs3cen=="FALSE"], pch=16)
points(jitter(rep(5, length(CAs5[CAs5cen=="TRUE"])), 2),
                CAs5[CAs5cen=="TRUE"], pch=1)
points(jitter(rep(5, length(CAs5[CAs5cen=="FALSE"])), 2),
                CAs5[CAs5cen=="FALSE"], pch=16)
points(jitter(rep(6, length(TAs5[TAs5cen=="TRUE"])), 2),
                TAs5[TAs5cen=="TRUE"], pch=1)
points(jitter(rep(6, length(TAs5[TAs5cen=="FALSE"])), 2),
                TAs5[TAs5cen=="FALSE"], pch=16)
box()


win.graph(height=7, width=11)
par(pty="m", mar=c(2,5,2,5),mgp=c(3,.5,0))
boxplot(CAs0, CAs3, CAs5, ylim=c(0, 1.2), axes=FALSE, pars=splus, outline=FALSE)
abline(h=0.6, lty=8)
abline(h=2.0, lty=8)
axis(side=2, at=seq(from=0, to=1.2, by=0.2))
```

```
axis(side=1, at=c(1, 2, 3), labels=c("Control Day 0", "Control Day 3", "Control Day 5"))
axis(side=4, at=2.0, label="LOQ = 2.0", cex.axis=0.65, las=1)
axis(side=4, at=0.6, label="LOQ = 0.6", cex.axis=0.65, las=1)
points(jitter(rep(1, length(CAs0[CAs0cen=="TRUE"])), 2),
              CAs0[CAs0cen=="TRUE"], pch=1)
points(jitter(rep(1, length(CAs0[CAs0cen=="FALSE"])), 2),
              CAs0[CAs0cen=="FALSE"], pch=16)
points(jitter(rep(3, length(CAs3[CAs3cen=="TRUE"])), 2),
              CAs3[CAs3cen=="TRUE"], pch=1)
points(jitter(rep(3, length(CAs3[CAs3cen=="FALSE"])), 2),
              CAs3[CAs3cen=="FALSE"], pch=16)
points(jitter(rep(5, length(CAs5[CAs5cen=="TRUE"])), 2),
              CAs5[CAs5cen=="TRUE"], pch=1)
points(jitter(rep(5, length(CAs5[CAs5cen=="FALSE"])), 2),
              CAs5[CAs5cen=="FALSE"], pch=16)
box()
```

Project:	Inorganic Arsenic in Poultry
Scientist:	Joe Kawalek, Ph.D.
Subject:	Non-inorganic As Analyses: DMA, MMA, 2-amino, N-acetyl, Roxarsone, Unknowns 3.5, 4.5, 5.5, 13, 21, 32 and 36
Author:	Vicki Lancaster, Ph.D.
Date:	September 17, 2010

This report contains the descriptive statistics for the 12 non-iAs variables: inorganic metabolites DMA and MMA, Roxarsone metabolites 3-amino and N-acetyl, Roxarsone, and the unknowns 3.5, 4.5, 5.5, 13, 21, 32 and 36. Concentrations for all 12 variables were censored at the 2.0 ppb limit of quantification.

Box plots of the 12 variables are displayed separately by treated and control over the withdrawal days, 0, 3 and 5, in Figures 1-12 (pages 5–10). The box plots were constructed (estimates of the lower, middle and upper quartile) without taking into account the censored values (below the LOQ) and using the values as reported by the laboratory. The box plots are for visualization and not inferential purposes. To aid in interpretation, filled and unfilled symbols have been overlain on the box plots to identify the values above and below the LOQ(s). Descriptive statistics are displayed in Tables 1-12 (pages 2 – 4). Due to censoring, descriptive statistics were estimated using the Kaplan-Meier estimator (Helsel, 2005 and Nelson, 1982).

Table 1. Kaplan Meier Descriptive Statistics by Withdrawal Day for DMA

Withdrawal Day	Group	N	Number / Percent Censored	Median	Mean	Standard Deviation
0	Control	8	8 / (100.00%)	NA[1]	0	0
	Treated	16	15 / (93.75%)	NA	2.1	NA
3	Control	8	8 / (100.00%)	NA	0	0
	Treated	16	16 / (100.00%)	NA	0	0
5	Control	11	11 / (100.00%)	NA	0	0
	Treated	21	20 / (95.24%)	NA	3.6	NA

[1] NA = Not available, descriptive statistic cannot be estimated due to censoring.

Table 2. Kaplan Meier Descriptive Statistics by Withdrawal Day for MMA

1ithdrawal Day	Group	N	Number / Percent Censored	Median	Mean	Standard Deviation
0	Control	8	8 / (100.00%)	NA[1]	0	0
	Treated	16	14 / (87.50%)	NA	2.0	0.1
3	Control	8	8 / (100.00%)	NA	0	0
	Treated	16	16 / (100.00%)	NA	0	0
5	Control	11	11 / (100.00%)	NA	0	0
	Treated	21	21 / (100.00%)	NA	0	0

[1] NA = Not available, descriptive statistic cannot be estimated due to censoring.

Table 3. Kaplan Meier Descriptive Statistics by Withdrawal Day for 3-amino

1ithdrawal Day	Group	N	Number / Percent Censored	Median	Mean	Standard Deviation
0	Control	8	8 / (100.00%)	NA[1]	0	0
	Treated	16	0 / (0%)	39.5	68.3	70.7
3	Control	8	8 / (100.00%)	NA	0	0
	Treated	16	7 / (43.75%)	2.3	22.9	34.6
5	Control	11	11 / (100.00%)	NA	0	0
	Treated	21	7 / (33.33%)	4.9	16.7	31.3

[1] NA = Not available, descriptive statistic cannot be estimated due to censoring.

Table 4. Kaplan Meier Descriptive Statistics by Withdrawal Day for N-acetyl

1ithdrawal Day	Group	N	Number / Percent Censored	Median	Mean	Standard Deviation
0	Control	8	8 / (100.00%)	NA[1]	0	0
	Treated	16	2 / (12.50%)	8.0	8.5	4.7
3	Control	8	8 / (100.00%)	NA	0	0
	Treated	16	9 / (56.25%)	NA	5.9	8.6
5	Control	11	11 / (100.00%)	NA	0	0
	Treated	21	10 / (47.62%)	2.0	5.3	7.3

[1] NA = Not available, descriptive statistic cannot be estimated due to censoring.

Table 5. Kaplan Meier Descriptive Statistics by Withdrawal Day for Roxarsone

1ithdrawal Day	Group	N	Number / Percent Censored	Median	Mean	Standard Deviation
0	Control	8	8 / (100.00%)	NA[1]	0	0
	Treated	16	0 / (0%)	864.8	1272.0	1067.1
3	Control	8	7 / (87.50%)	NA	2.6	NA
	Treated	16	0 / (0%)	269.6	604.1	677.6
5	Control	11	11 / (100.00%)	NA	0	0
	Treated	21	0 / (0%)	161.6	231.6	260.3

[1] NA = Not available, descriptive statistic cannot be estimated due to censoring.

Table 6. Kaplan Meier Descriptive Statistics by Withdrawal Day for UNK 3.5

1ithdrawal Day	Group	N	Number / Percent Censored	Median	Mean	Standard Deviation
0	Control	8	8 / (100.00%)	NA[1]	0	0
	Treated	16	1 / (6.25%)	4.3	5.6	3.6
3	Control	8	8 / (100.00%)	NA	0	0
	Treated	16	11 / (68.75%)	NA	5.4	2.2
5	Control	11	11 / (100.00%)	NA	0	0
	Treated	21	15 / (71.43%)	NA	4.6	4.8

[1] NA = Not available, descriptive statistic cannot be estimated due to censoring.

Table 7. Kaplan Meier Descriptive Statistics by Withdrawal Day for UNK 4.5

1ithdrawal Day	Group	N	Number / Percent Censored	Median	Mean	Standard Deviation
0	Control	8	8 / (100.00%)	NA[1]	0	0
	Treated	16	15 / (93.75%)	NA	3.0	NA
3	Control	8	8 / (100.00%)	NA	0	0
	Treated	16	15 / (93.75%)	NA	2.1	NA
5	Control	11	11 / (100.00%)	NA	0	0
	Treated	21	21 / (100.00%)	NA	0	0

[1] NA = Not available, descriptive statistic cannot be estimated due to censoring.

Table 8. Kaplan Meier Descriptive Statistics by Withdrawal Day for UNK 5.5

1ithdrawal Day	Group	N	Number / Percent Censored	Median	Mean	Standard Deviation
0	Control	8	8 / (100.00%)	NA[1]	0	0
	Treated	16	0 / (0%)	70.3	74.4	45.2
3	Control	8	8 / (100.00%)	NA	0	0
	Treated	16	0 / (0%)	54.4	70.8	33.8
5	Control	11	11 / (100.00%)	NA	0	0
	Treated	21	0 / (0%)	35.5	41.2	19.1

[1] NA = Not available, descriptive statistic cannot be estimated due to censoring.

Table 9. Kaplan Meier Descriptive Statistics by Withdrawal Day for UNK 13

1ithdrawal Day	Group	N	Number / Percent Censored	Median	Mean	Standard Deviation
0	Control	8	8 / (100.00%)	NA[1]	0	0
	Treated	16	12 / (75.00%)	NA	2.2	0.4
3	Control	8	8 / (100.00%)	NA	0	0
	Treated	16	15 / (93.75%)	NA	3.6	NA
5	Control	11	11 / (100.00%)	NA	0	0
	Treated	21	19 / (90.45%)	NA	3.2	0.4

[1] NA = Not available, descriptive statistic cannot be estimated due to censoring.

Table 10. Kaplan Meier Descriptive Statistics by Withdrawal Day for UNK 21

1ithdrawal Day	Group	N	Number / Percent Censored	Median	Mean	Standard Deviation
0	Control	8	8 / (100.00%)	NA[1]	0	0
	Treated	16	2 / (12.50%)	8.3	12.0	10.4
3	Control	8	8 / (100.00%)	NA	0	0
	Treated	16	9 / (56.25%)	NA	3.9	3.3
5	Control	11	11 / (100.00%)	NA	0	0
	Treated	21	16 / (76.19%)	NA	3.4	4.4

[1] NA = Not available, descriptive statistic cannot be estimated due to censoring.

Table 11. Kaplan Meier Descriptive Statistics by Withdrawal Day for UNK 32

1ithdrawal Day	Group	N	Number / Percent Censored	Median	Mean	Standard Deviation
0	Control	0				
	Treated	0				
3	Control	8	8 / (100.00%)	NA	0	0
	Treated	16	11 / (63.75%)	NA	6.8	0.7
5	Control	11	11 / (100.00%)	NA	0	0
	Treated	21	8 / (38.09%)	3.7	9.0	11.8

[1] NA = Not available, descriptive statistic cannot be estimated due to censoring.

Table 12. Kaplan Meier Descriptive Statistics by Withdrawal Day for UNK 36

1ithdrawal Day	Group	N	Number / Percent Censored	Median	Mean	Standard Deviation
0	Control	8	8 / (100.00%)	NA[1]	0	0
	Treated	16	0 / (0%)	107.3	129.3	74.9
3	Control	8	8 / (100.00%)	NA	0	0
	Treated	16	0 / (0%)	45.0	90.4	79.3
5	Control	11	11 / (100.00%)	NA	0	0
	Treated	21	0 / (0%)	41.4	54.3	45.0

[1] NA = Not available, descriptive statistic cannot be estimated due to censoring.

Figure 1. Box Plots of As Metabolite DMA (ppb) for Treated and Control Birds by Withdrawal Day
(Open Circles = Censored, Filled Circles = Uncensored; Dotted horizontal line is at the limit of quantification)

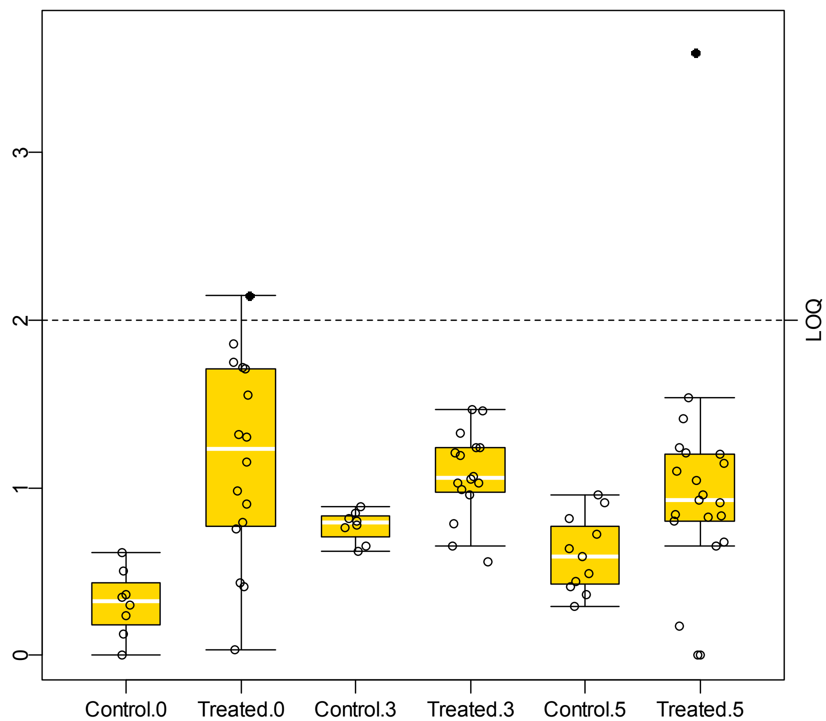


Figure 2. Box Plots of As Metabolite MMA (ppb) for Treated and Control Birds by Withdrawal Day
(Open Circles = Censored, Filled Circles = Uncensored; Dotted horizontal line is at the limit of quantification)

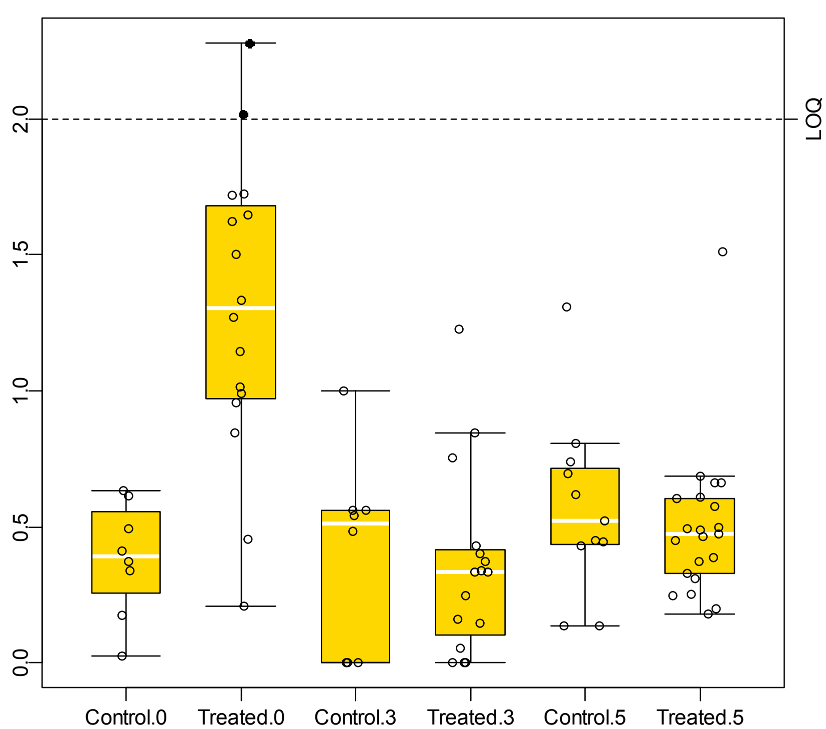


Figure 3. Box Plots of Roxarsone Metabolite 3-amino (ppb)
for Treated and Control Birds by Withdrawal Day
(Open Circles = Censored, Filled Circles = Uncensored; Dotted horizontal line is at the limit of quantification)

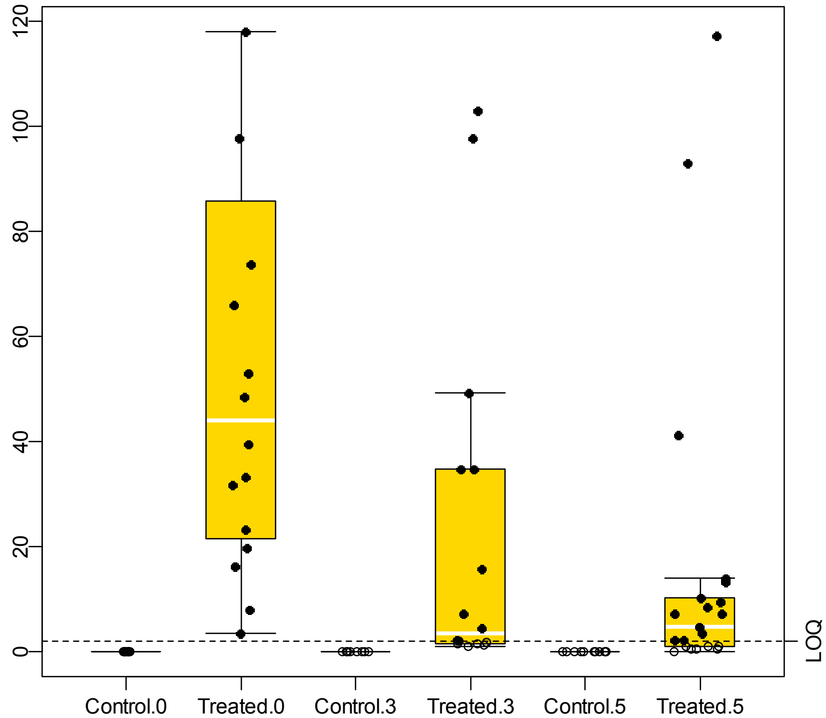


Figure 4. Box Plots of Roxarsone Metabolite N-acetyl (ppb)
for Treated and Control Birds by Withdrawal Day
(Open Circles = Censored, Filled Circles = Uncensored; Dotted horizontal line is at the limit of quantification)

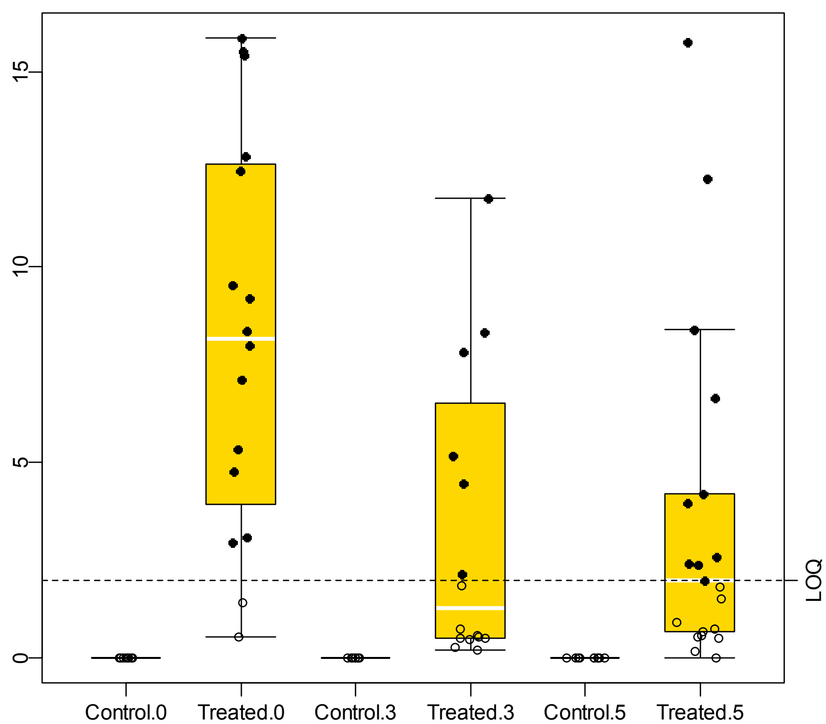


Figure 5. Box Plots of Roxarsone (ppb) for Treated and Control Birds by Withdrawal Day
(Open Circles = Censored, Filled Circles = Uncensored; Dotted horizontal line is at the limit of quantification)

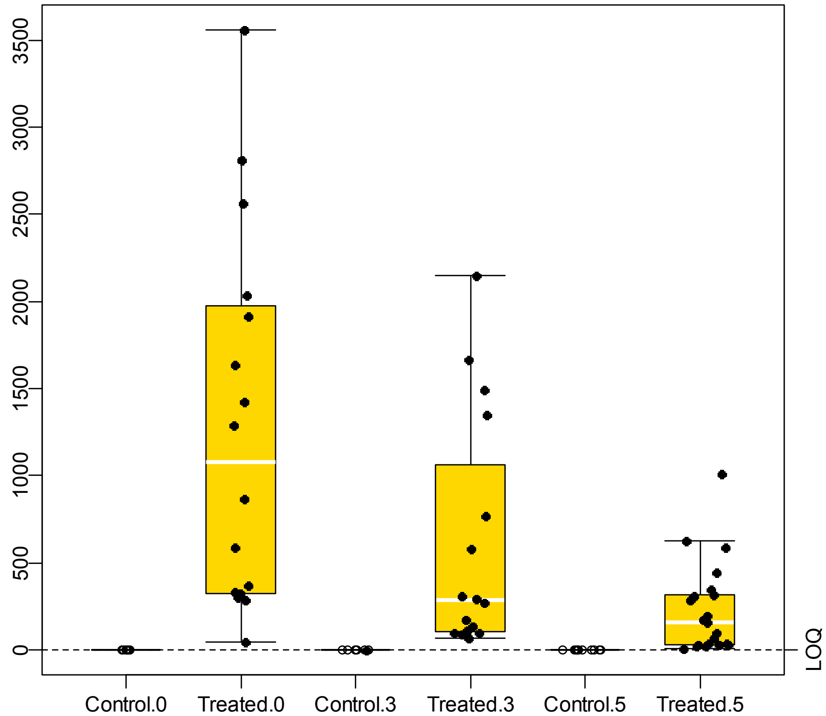


Figure 6. Box Plots of Unknown 3.5 (ppb) for Treated and Control Birds by Withdrawal Day
(Open Circles = Censored, Filled Circles = Uncensored; Dotted horizontal line is at the limit of quantification)

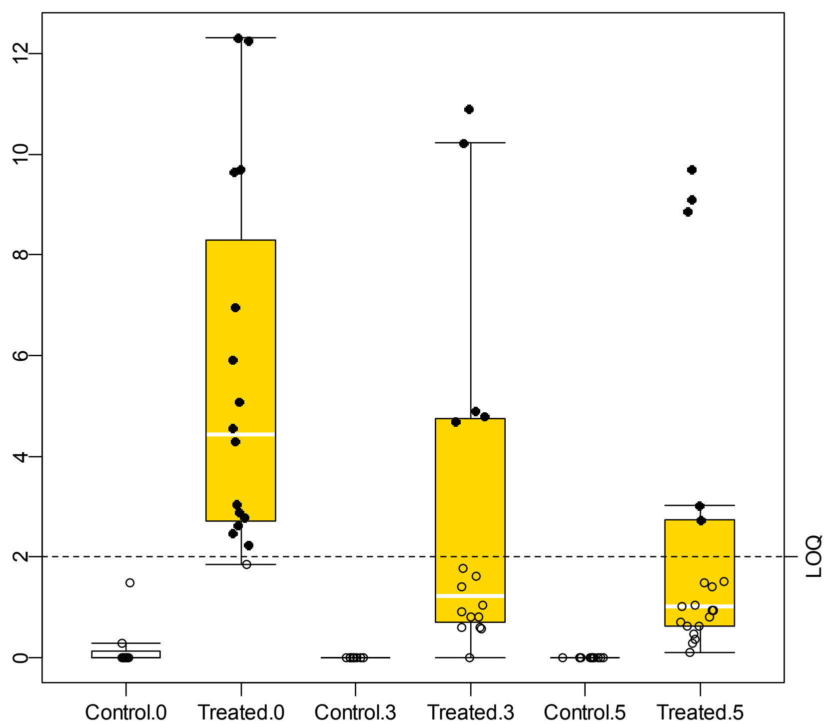


Figure 7. Box Plots of Unknown 4.5 (ppb) for Treated and Control Birds by Withdrawal Day
(Open Circles = Censored, Filled Circles = Uncensored; Dotted horizontal line is at the limit of quantification)

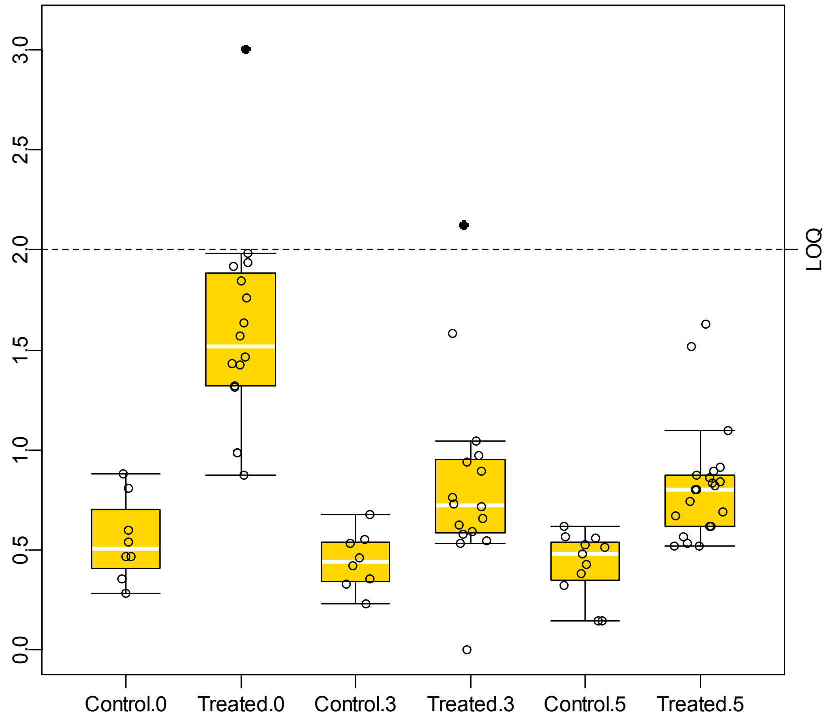


Figure 8. Box Plots of Unknown 5.5 (ppb) for Treated and Control Birds by Withdrawal Day
(Open Circles = Censored, Filled Circles = Uncensored; Dotted horizontal line is at the limit of quantification)

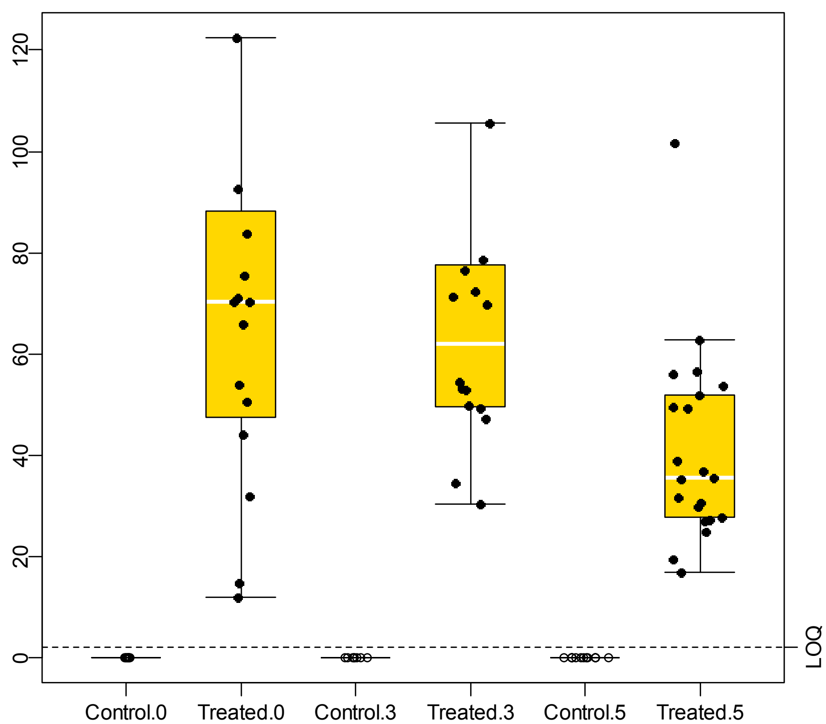


Figure 9. Box Plots of Unknown 13 (ppb) for Treated and Control Birds by Withdrawal Day
(Open Circles = Censored, Filled Circles = Uncensored; Dotted horizontal line is at the limit of quantification)

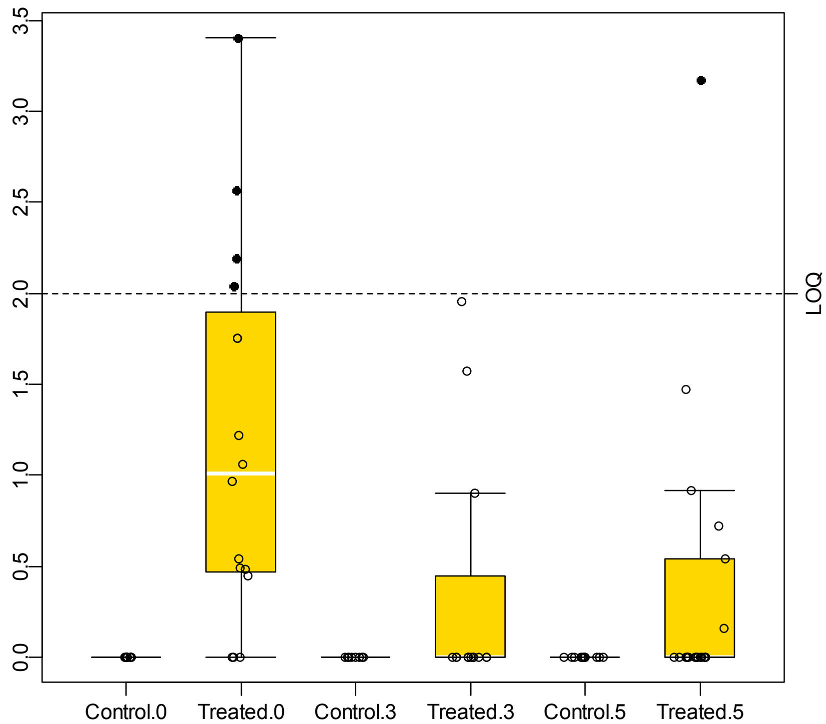


Figure 10. Box Plots of Unknown 21 (ppb) for Treated and Control Birds by Withdrawal Day
(Open Circles = Censored, Filled Circles = Uncensored; Dotted horizontal line is at the limit of quantification)

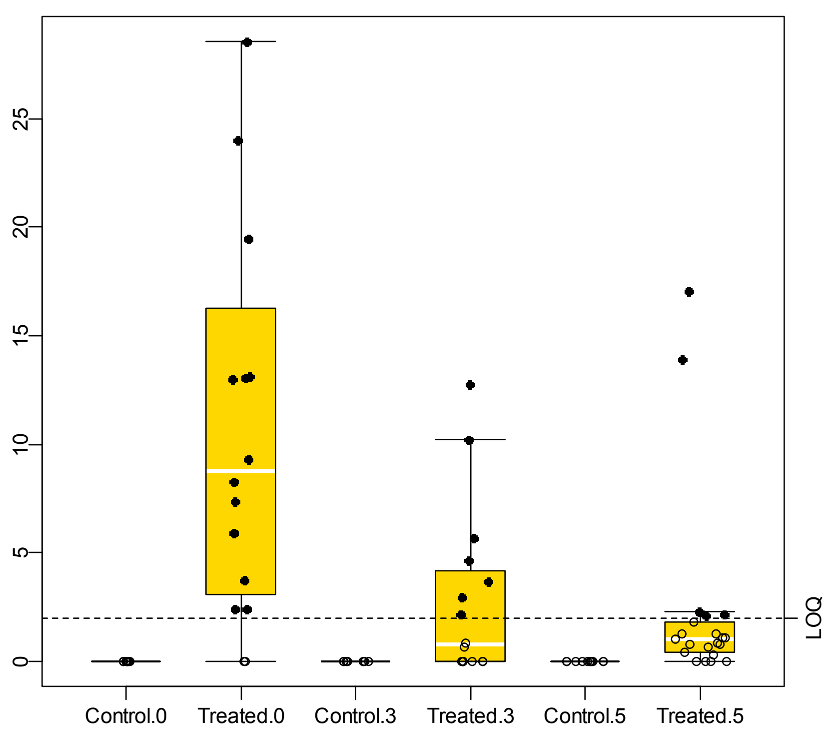


Figure 11. Box Plots of Unknown 32 (ppb) for Treated and Control Birds by Withdrawal Day
(Open Circles = Censored, Filled Circles = Uncensored; Dotted horizontal line is at the limit of quantification)

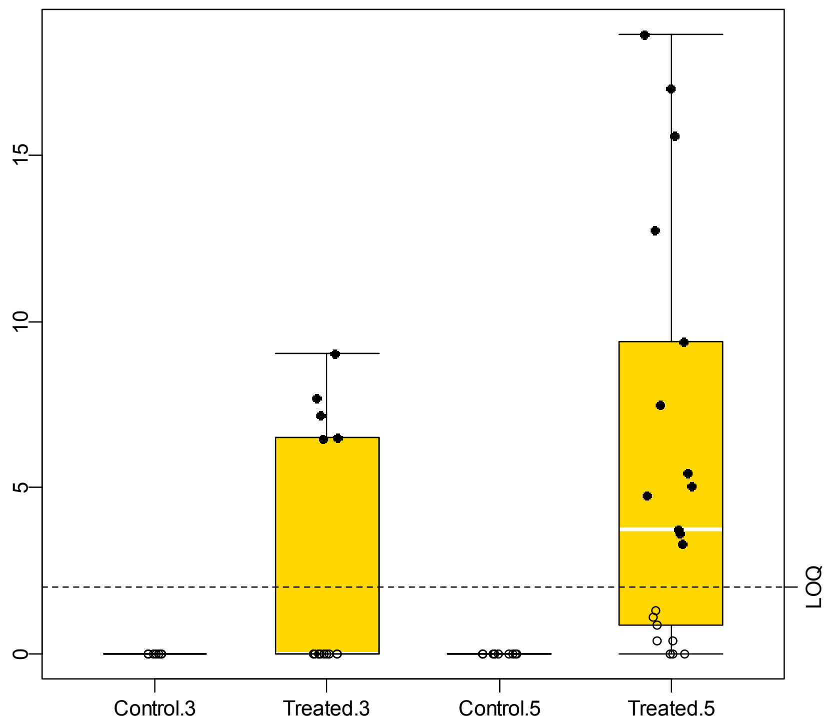
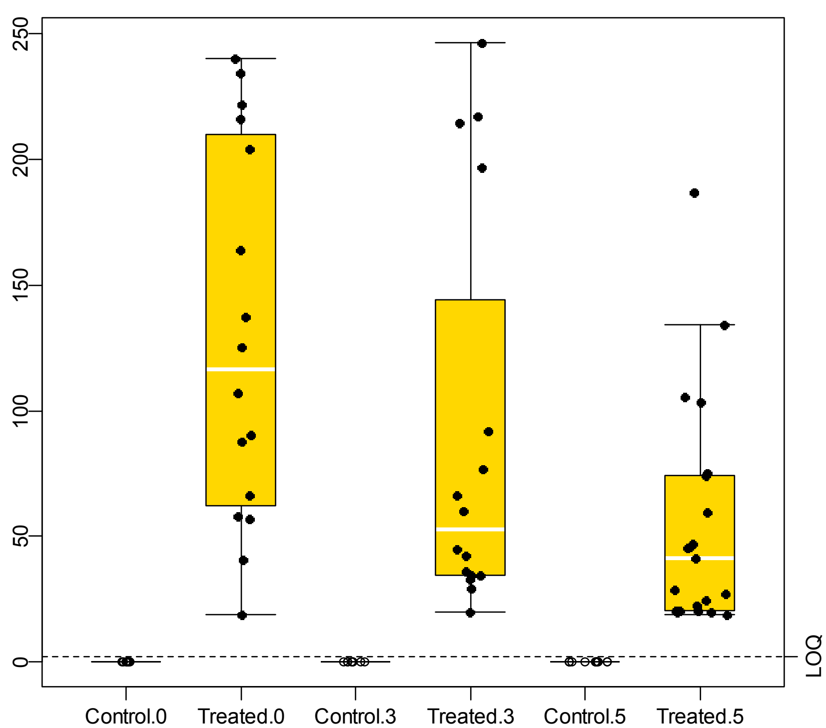


Figure 12. Box Plots of Unknown 36 (ppb) for Treated and Control Birds by Withdrawal Day
(Open Circles = Censored, Filled Circles = Uncensored; Dotted horizontal line is at the limit of quantification)



References

Helsel, Dennis R. (2005). Nondetects and Data Analysis: Statistics for censored environmental data. John Wiley & Sons, Inc., USA.

Nelson, Wayne (1982). Applied Life Data Analysis. John Wiley & Sons, Inc., USA.

R Development Core Team, R: A Language and Environment for Statistical Computing, R Foundation for Statistical Computing, Vienna, Austria, 2008 http://www.R-project.org

Appendix

How to Interpret a Box plot:

A ***box plot*** is a rectangle, the top and bottom of the rectangle are located at the upper and lower quartiles of the data; the horizontal white line within the rectangle is located at the median. Lines in the shape of a "T" extend from the box to the nearest value not beyond the ***standard span*** from the quartiles. These lines are often referred to as whiskers. Values beyond the end of the whiskers are drawn individually as filled circles. Box plots that are symmetric indicate a bell-shaped distribution.

The ***standard span*** is 1.5 times the ***inter-quartile range*** (IQR).

The ***quantile*** of the data is a number that divides the data into two groups, so that a fraction of the observations fall below the quantile and a fraction lie above the quantile. For example, the 75^{th} quantile (Q(.75)) divides the data set such the three fourths of the observations fall below Q(.75) and one fourth lie above.

- The ***median*** is the 50^{th} quantile, Q(.50).
- The ***upper quartile*** is the 75^{th} quantile, Q(.75).
- The ***lower quartile*** is the 25^{th} quantile, Q(.25).
- The ***IQR*** = Q(.75) – Q(.25).