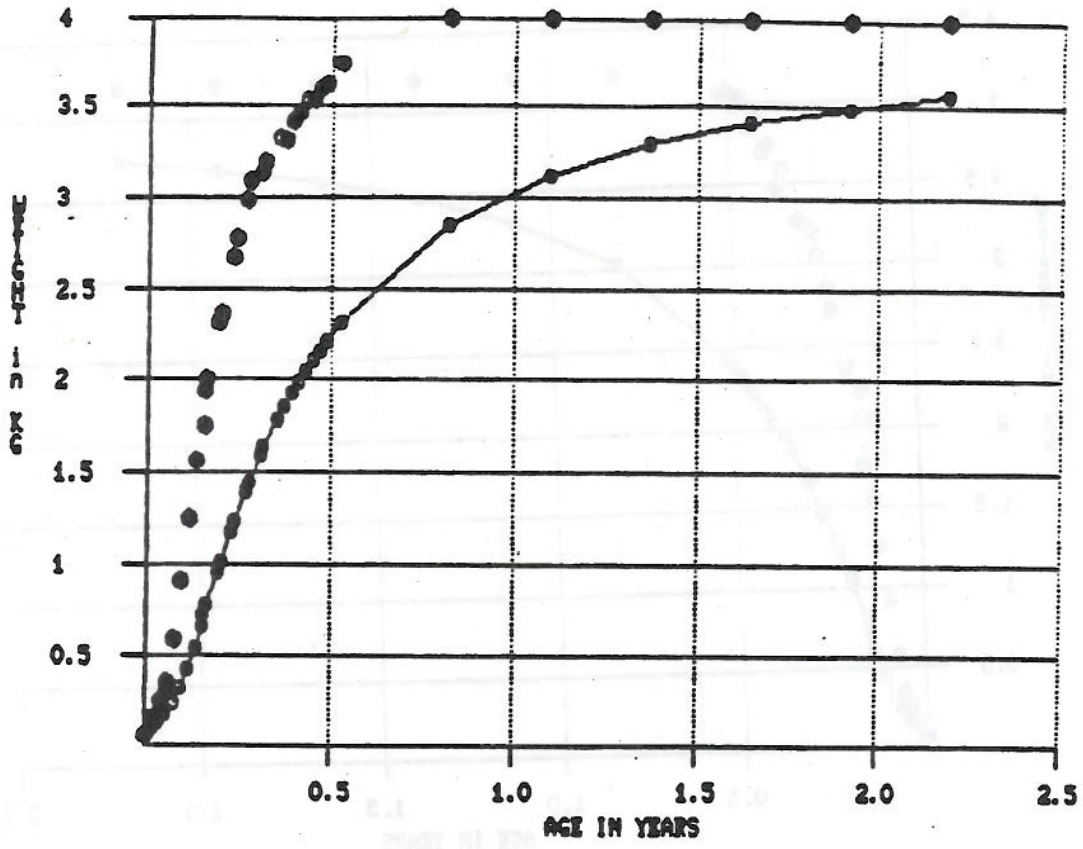


FIGURE 3-49

Recommended Growth Curve for Male New Zealand White Rabbits

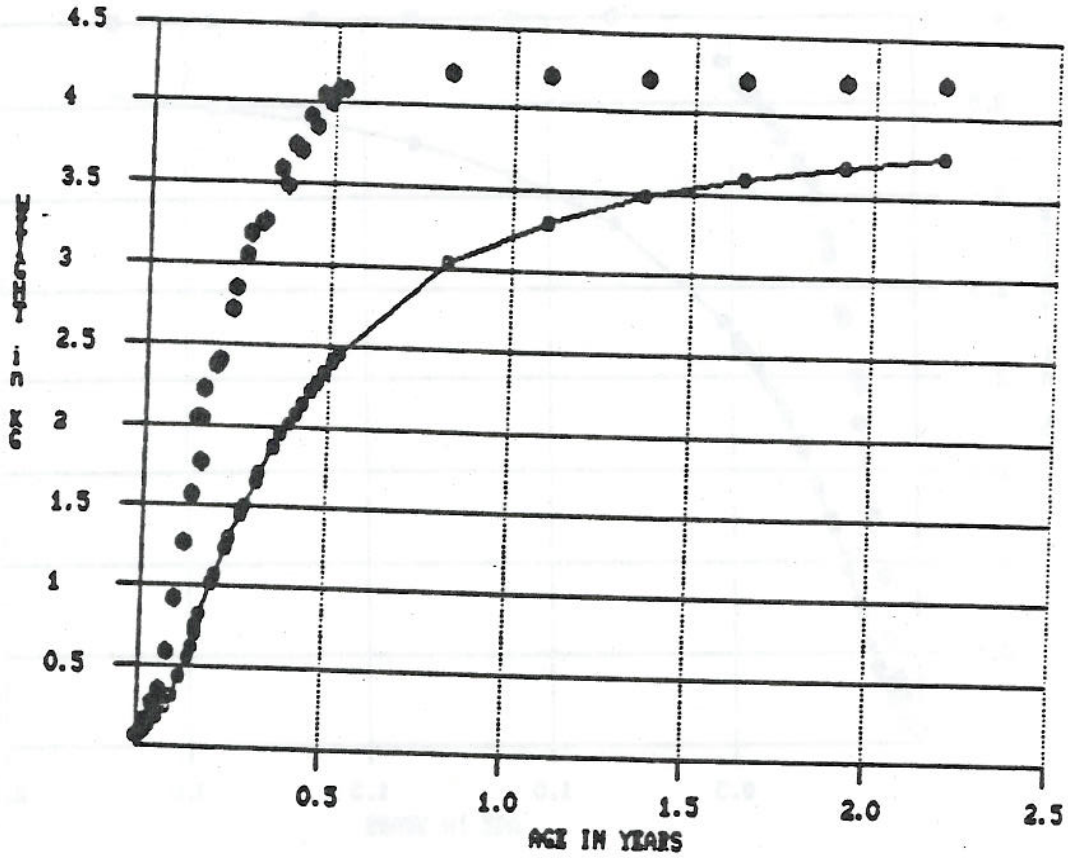


FIGURE 3-50

Recommended Growth Curve for Female New Zealand White Rabbits

3.4. LIVESTOCK

Body and growth data on livestock are summarized in Table 3-12. Body weight data on most strains of livestock are provided primarily to facilitate the demonstration of allometric relationships discussed in subsequent sections of this report. Nonetheless, information on the body weights and consumption patterns of livestock may be useful in risk assessments when an attempt is made to estimate doses in cases of accidental exposure of livestock to toxicants.

3.4.1. Cattle. Growth data on all strains of cattle presented in Table 3-12 are plotted in Figure 3-51. Hereford cattle are clear outliers that reach a mature body weight of ~1200 kg, and the data on this breed are presented separately in Figure 3-52. Other breeds of cattle on which data are available reach mature body weights of ~400-550 kg. Data on these strains are summarized in Figure 3-53. Because cattle are not used in toxicity studies, recommended body weights other than mature body weights are not derived.

3.4.2. Chickens. Growth data on all strains of chickens summarized in Table 3-12 are plotted in Figure 3-54. The variability in the body weights and growth rates of chickens appears to be greater than in most other species of animals included in this report. The smallest strains are crosses of "desi" and White Leghorn strains reported in the Indian literature (Sah et al., 1984) and an unspecified strain of broiler chicken reported in the Eastern European literature (Knizetove et al., 1985). The largest and fastest growing stain on which data are available is the Ross broiler (Prescott et al., 1985).

TABLE 3-12

Growth and Body Weight Data on Livestock

Species	Strain	Sex	No. of Animals	Age (days)	Weight (kg)	Variance	Reference
Cattle	Guernsey, fg	female	1	1460	460.00000	NS	Amoroso et al., 1964
Cattle	Guernsey, fg	female	1	2920	410.00000	NS	Amoroso et al., 1964
Cattle	Jersey	female	1	730	340.00000	NS	Amoroso et al., 1964
Cattle	Several	male	many	112	94.00000	NS	Taylor et al., 1986
Cattle	Several	male	many	140	111.00000	NS	Taylor et al., 1986
Cattle	Several	male	many	158	133.00000	NS	Taylor et al., 1986
Cattle	Several	male	many	186	159.00000	NS	Taylor et al., 1986
Cattle	Several	male	many	224	184.00000	NS	Taylor et al., 1986
Cattle	Several	male	many	252	210.00000	NS	Taylor et al., 1986
Cattle	Several	male	many	276	256.00000	NS	Taylor et al., 1986
Cattle	Several	male	many	280	233.00000	NS	Taylor et al., 1986
Cattle	Several	male	many	336	278.00000	NS	Taylor et al., 1986
Cattle	Several	male	many	364	299.00000	NS	Taylor et al., 1986
Cattle	Several	male	many	392	319.00000	NS	Taylor et al., 1986
Cattle	Several	male	many	420	338.00000	NS	Taylor et al., 1986
Cattle	Several	male	many	448	358.00000	NS	Taylor et al., 1986
Cattle	Several	male	many	476	376.00000	NS	Taylor et al., 1986
Cattle	Ayrshire	female	NS	300	200.00000	NS	Campbell and Lasley, 1975
Cattle	Ayrshire	female	NS	600	300.00000	NS	Campbell and Lasley, 1975
Cattle	Ayrshire	female	NS	900	360.00000	NS	Campbell and Lasley, 1975
Cattle	Ayrshire	female	NS	1200	400.00000	NS	Campbell and Lasley, 1975
Cattle	Ayrshire	female	NS	1500	425.00000	NS	Campbell and Lasley, 1975
Cattle	Ayrshire	female	NS	1800	440.00000	NS	Campbell and Lasley, 1975
Cattle	Ayrshire	female	NS	2100	450.00000	NS	Campbell and Lasley, 1975
Cattle	Ayrshire	female	NS	3600	455.00000	NS	Campbell and Lasley, 1975
Cattle	Hereford	female	NS	360	780.00000	NS	Campbell and Lasley, 1975
Cattle	Hereford	female	NS	720	860.00000	NS	Campbell and Lasley, 1975
Cattle	Hereford	female	NS	1080	960.00000	NS	Campbell and Lasley, 1975
Cattle	Hereford	female	NS	1440	1030.00000	NS	Campbell and Lasley, 1975
Cattle	Hereford	female	NS	1800	1100.00000	NS	Campbell and Lasley, 1975
Cattle	Hereford	female	NS	2160	1140.00000	NS	Campbell and Lasley, 1975
Cattle	Hereford	female	NS	2520	1150.00000	NS	Campbell and Lasley, 1975
Cattle	Hereford	female	NS	2880	1160.00000	NS	Campbell and Lasley, 1975
Cattle	Hereford	female	NS	3240	1155.00000	NS	Campbell and Lasley, 1975
Cattle	Hereford	female	NS	3600	1140.00000	NS	Campbell and Lasley, 1975
Cattle	Hereford	female	NS	3960	1095.00000	NS	Campbell and Lasley, 1975

TABLE 3-12 (cont.)

Species	Strain	Sex	No. of Animals	Age (days)	Weight (kg)	Variance	Reference
Cattle	Holstein	female	NS	300	225.00000	NS	Campbell and Lasley, 1975
Cattle	Holstein	female	NS	600	355.00000	NS	Campbell and Lasley, 1975
Cattle	Holstein	female	NS	900	425.00000	NS	Campbell and Lasley, 1975
Cattle	Holstein	female	NS	1200	475.00000	NS	Campbell and Lasley, 1975
Cattle	Holstein	female	NS	1500	505.00000	NS	Campbell and Lasley, 1975
Cattle	Holstein	female	NS	1800	525.00000	NS	Campbell and Lasley, 1975
Cattle	Holstein	female	NS	2100	535.00000	NS	Campbell and Lasley, 1975
Cattle	Holstein	female	NS	2700	540.00000	NS	Campbell and Lasley, 1975
Cattle	Holstein	female	NS	3600	550.00000	NS	Campbell and Lasley, 1975
Cattle	Jersey	female	NS	300	200.00000	NS	Campbell and Lasley, 1975
Cattle	Jersey	female	NS	600	280.00000	NS	Campbell and Lasley, 1975
Cattle	Jersey	female	NS	900	340.00000	NS	Campbell and Lasley, 1975
Cattle	Jersey	female	NS	1200	370.00000	NS	Campbell and Lasley, 1975
Cattle	Jersey	female	NS	1500	390.00000	NS	Campbell and Lasley, 1975
Cattle	Jersey	female	NS	1800	415.00000	NS	Campbell and Lasley, 1975
Cattle	Jersey	female	NS	3600	420.00000	NS	Campbell and Lasley, 1975
Cattle	NS	NS	20	4	44.20000	NS	Kertz et al., 1984
Cattle	NS	NS	20	11	44.43000	NS	Kertz et al., 1984
Cattle	NS	NS	20	18	44.11000	NS	Kertz et al., 1984
Cattle	NS	NS	20	25	47.20000	NS	Kertz et al., 1984
Cattle	NS	NS	20	31	52.65000	NS	Kertz et al., 1984
Chicken	Broiler	female	32	120	0.45000	NS	Knizetova et al., 1985
Chicken	Broiler	female	32	180	0.60000	NS	Knizetova et al., 1985
Chicken	Broiler	female	32	240	1.10000	NS	Knizetova et al., 1985
Chicken	Broiler	female	32	360	2.15000	NS	Knizetova et al., 1985
Chicken	Broiler	female	32	480	2.95000	NS	Knizetova et al., 1985
Chicken	Broiler	female	32	600	3.50000	NS	Knizetova et al., 1985
Chicken	Broiler	female	32	660	3.65000	NS	Knizetova et al., 1985
Chicken	Broiler	female	32	720	3.75000	NS	Knizetova et al., 1985
Chicken	Broiler	female	32	780	3.80000	NS	Knizetova et al., 1985
Chicken	Broiler	female	32	840	3.80000	NS	Knizetova et al., 1985
Chicken	Broiler	male	11	120	0.45000	NS	Knizetova et al., 1985
Chicken	Broiler	male	11	180	0.75000	NS	Knizetova et al., 1985
Chicken	Broiler	male	11	240	1.20000	NS	Knizetova et al., 1985
Chicken	Broiler	male	11	360	2.60000	NS	Knizetova et al., 1985
Chicken	Broiler	male	11	480	4.00000	NS	Knizetova et al., 1985
Chicken	Broiler	male	11	660	4.80000	NS	Knizetova et al., 1985
Chicken	Broiler	male	11	720	5.05000	NS	Knizetova et al., 1985
Chicken	Broiler	male	11	780	5.20000	NS	Knizetova et al., 1985
Chicken	Broiler	male	11	840	5.25000	NS	Knizetova et al., 1985

TABLE 3-12 (cont.)

Species	Strain	Sex	No. of Animals	Age (days)	Weight (kg)	Variance	Reference
Chicken	Cornish	female	NS	1	0.03200	NS	Altman and Dittmer, 1974
Chicken	Cornish	female	NS	7	0.05900	NS	Altman and Dittmer, 1974
Chicken	Cornish	female	NS	14	0.10500	NS	Altman and Dittmer, 1974
Chicken	Cornish	female	NS	21	0.17200	NS	Altman and Dittmer, 1974
Chicken	Cornish	female	NS	28	0.25600	NS	Altman and Dittmer, 1974
Chicken	Cornish	female	NS	35	NS	NS	Altman and Dittmer, 1974
Chicken	Cornish	female	NS	42	NS	NS	Altman and Dittmer, 1974
Chicken	Cornish	female	NS	49	NS	NS	Altman and Dittmer, 1974
Chicken	Cornish	female	NS	56	0.63600	NS	Altman and Dittmer, 1974
Chicken	Cornish	female	NS	63	NS	NS	Altman and Dittmer, 1974
Chicken	Cornish	female	NS	70	NS	NS	Altman and Dittmer, 1974
Chicken	Cornish	female	NS	84	1.04500	NS	Altman and Dittmer, 1974
Chicken	Cornish	female	NS	98	NS	NS	Altman and Dittmer, 1974
Chicken	Cornish	female	NS	112	1.31800	NS	Altman and Dittmer, 1974
Chicken	Cornish	female	NS	126	NS	NS	Altman and Dittmer, 1974
Chicken	Cornish	female	NS	140	1.54500	NS	Altman and Dittmer, 1974
Chicken	Cornish	male	NS	1	0.03200	NS	Altman and Dittmer, 1974
Chicken	Cornish	male	NS	7	0.05900	NS	Altman and Dittmer, 1974
Chicken	Cornish	male	NS	14	0.10900	NS	Altman and Dittmer, 1974
Chicken	Cornish	male	NS	21	0.18200	NS	Altman and Dittmer, 1974
Chicken	Cornish	male	NS	28	0.26800	NS	Altman and Dittmer, 1974
Chicken	Cornish	male	NS	35	NS	NS	Altman and Dittmer, 1974
Chicken	Cornish	male	NS	42	NS	NS	Altman and Dittmer, 1974
Chicken	Cornish	male	NS	49	NS	NS	Altman and Dittmer, 1974
Chicken	Cornish	male	NS	56	0.72700	NS	Altman and Dittmer, 1974
Chicken	Cornish	male	NS	63	NS	NS	Altman and Dittmer, 1974
Chicken	Cornish	male	NS	70	NS	NS	Altman and Dittmer, 1974
Chicken	Cornish	male	NS	84	1.27200	NS	Altman and Dittmer, 1974
Chicken	Cornish	male	NS	98	NS	NS	Altman and Dittmer, 1974
Chicken	Cornish	male	NS	112	1.72700	NS	Altman and Dittmer, 1974
Chicken	Cornish	male	NS	126	NS	NS	Altman and Dittmer, 1974
Chicken	Cornish	male	NS	140	2.09100	NS	Altman and Dittmer, 1974
Chicken	I/1+ C+/-	both	135	42	0.55590	NS	Fox and Smyth, 1985
Chicken	I/1+ C+/-	both	135	56	0.81510	NS	Fox and Smyth, 1985
Chicken	I/1+ c/c	both	123	42	0.45740	NS	Fox and Smyth, 1985
Chicken	I/1+ c/c	both	123	56	0.80490	NS	Fox and Smyth, 1985
Chicken	1+/1+ C+/-	both	123	42	0.57040	NS	Fox and Smyth, 1985
Chicken	1+/1+ c/c	both	121	42	0.53280	NS	Fox and Smyth, 1985
Chicken	1+/1+ c/c	both	121	56	0.78600	NS	Fox and Smyth, 1985
Chicken	1+/1+ C+/-	both	123	56	0.84170	NS	Fox and Smyth, 1985

TABLE 3-12 (cont.)

Species	Strain	Sex	No. of Animals	Age (days)	Weight (kg)	Variance	Reference
Chicken	New Hampshire	female	NS	1	0.03600	NS	Altman and Dittmer, 1974
Chicken	New Hampshire	female	NS	7	0.08200	NS	Altman and Dittmer, 1974
Chicken	New Hampshire	female	NS	14	0.15400	NS	Altman and Dittmer, 1974
Chicken	New Hampshire	female	NS	21	0.25000	NS	Altman and Dittmer, 1974
Chicken	New Hampshire	female	NS	28	0.36300	NS	Altman and Dittmer, 1974
Chicken	New Hampshire	female	NS	35	0.50400	NS	Altman and Dittmer, 1974
Chicken	New Hampshire	female	NS	42	0.64000	NS	Altman and Dittmer, 1974
Chicken	New Hampshire	female	NS	49	0.80700	NS	Altman and Dittmer, 1974
Chicken	New Hampshire	female	NS	56	0.94800	NS	Altman and Dittmer, 1974
Chicken	New Hampshire	female	NS	63	1.10700	NS	Altman and Dittmer, 1974
Chicken	New Hampshire	female	NS	70	1.28400	NS	Altman and Dittmer, 1974
Chicken	New Hampshire	female	NS	84	1.55100	NS	Altman and Dittmer, 1974
Chicken	New Hampshire	female	NS	98	1.82800	NS	Altman and Dittmer, 1974
Chicken	New Hampshire	female	NS	112	2.01900	NS	Altman and Dittmer, 1974
Chicken	New Hampshire	female	NS	126	2.25400	NS	Altman and Dittmer, 1974
Chicken	New Hampshire	female	NS	140	2.30900	NS	Altman and Dittmer, 1974
Chicken	New Hampshire	male	NS	1	0.04100	NS	Altman and Dittmer, 1974
Chicken	New Hampshire	male	NS	7	0.08600	NS	Altman and Dittmer, 1974
Chicken	New Hampshire	male	NS	14	0.15400	NS	Altman and Dittmer, 1974
Chicken	New Hampshire	male	NS	21	0.27200	NS	Altman and Dittmer, 1974
Chicken	New Hampshire	male	NS	28	0.40400	NS	Altman and Dittmer, 1974
Chicken	New Hampshire	male	NS	35	0.56300	NS	Altman and Dittmer, 1974
Chicken	New Hampshire	male	NS	42	0.73500	NS	Altman and Dittmer, 1974
Chicken	New Hampshire	male	NS	49	0.93400	NS	Altman and Dittmer, 1974
Chicken	New Hampshire	male	NS	56	1.15200	NS	Altman and Dittmer, 1974
Chicken	New Hampshire	male	NS	63	1.32500	NS	Altman and Dittmer, 1974
Chicken	New Hampshire	male	NS	70	1.62800	NS	Altman and Dittmer, 1974
Chicken	New Hampshire	male	NS	84	1.84900	NS	Altman and Dittmer, 1974
Chicken	New Hampshire	male	NS	98	2.55400	NS	Altman and Dittmer, 1974
Chicken	New Hampshire	male	NS	112	2.99400	NS	Altman and Dittmer, 1974
Chicken	New Hampshire	male	NS	126	3.29300	NS	Altman and Dittmer, 1974
Chicken	New Hampshire	male	NS	140	3.37500	NS	Altman and Dittmer, 1974
Chicken	Ross broiler	male	3	1	0.04400	NS	Prescott et al., 1985
Chicken	Ross broiler	male	3	1	0.04400	NS	Prescott et al., 1985
Chicken	Ross broiler	male	3	7	0.16400	NS	Prescott et al., 1985
Chicken	Ross broiler	male	3	14	0.33400	NS	Prescott et al., 1985
Chicken	Ross broiler	male	3	21	0.76500	NS	Prescott et al., 1985
Chicken	Ross broiler	male	3	28	1.15500	NS	Prescott et al., 1985
Chicken	Ross broiler	male	3	35	1.53900	NS	Prescott et al., 1985
Chicken	Ross broiler	male	3	42	1.77800	NS	Prescott et al., 1985
Chicken	Ross broiler	male	3	49	2.33400	NS	Prescott et al., 1985
Chicken	Ross broiler	male	3	63	3.25400	NS	Prescott et al., 1985
Chicken	Ross broiler	male	3	77	3.93400	NS	Prescott et al., 1985

TABLE 3-12 (cont.)

Species	Strain	Sex	No. of Animals	Age (days)	Weight (kg)	Variance	Reference
Chicken	Ross broiler	male	3	91	4.73000	NS	Prescott et al., 1985
Chicken	Ross broiler	male	3	105	5.46000	NS	Prescott et al., 1985
Chicken	Ross broiler	male	3	119	5.75800	NS	Prescott et al., 1985
Chicken	Ross broiler	male	3	140	6.49000	NS	Prescott et al., 1985
Chicken	Ross broiler	male	2	161	6.50000	NS	Prescott et al., 1985
Chicken	Several	female	44	1	0.02710	4.00E-006	Sah et al., 1984
Chicken	Several	female	44	28	0.07510	2.30E-005	Sah et al., 1984
Chicken	Several	female	18	84	0.32750	3.42E-004	Sah et al., 1984
Chicken	Several	female	18	140	0.65720	2.18E-003	Sah et al., 1984
Chicken	Several	male	36	1	0.02900	4.20E-006	Sah et al., 1984
Chicken	Several	male	36	28	0.08740	2.07E-005	Sah et al., 1984
Chicken	Several	male	27	84	0.38790	1.08E-003	Sah et al., 1984
Chicken	Several	male	16	140	0.74480	2.72E-004	Sah et al., 1984
Chicken	White Leghorn	female	NS	1	0.03600	NS	Altman and Dittmer, 1974
Chicken	White Leghorn	female	NS	7	0.07300	NS	Altman and Dittmer, 1974
Chicken	White Leghorn	female	NS	14	0.11800	NS	Altman and Dittmer, 1974
Chicken	White Leghorn	female	NS	21	0.19500	NS	Altman and Dittmer, 1974
Chicken	White Leghorn	female	NS	28	0.27200	NS	Altman and Dittmer, 1974
Chicken	White Leghorn	female	NS	35	0.36700	NS	Altman and Dittmer, 1974
Chicken	White Leghorn	female	NS	42	0.43600	NS	Altman and Dittmer, 1974
Chicken	White Leghorn	female	NS	49	0.54900	NS	Altman and Dittmer, 1974
Chicken	White Leghorn	female	NS	56	0.64000	NS	Altman and Dittmer, 1974
Chicken	White Leghorn	female	NS	63	0.72100	NS	Altman and Dittmer, 1974
Chicken	White Leghorn	female	NS	70	0.77600	NS	Altman and Dittmer, 1974
Chicken	White Leghorn	female	NS	84	0.93400	NS	Altman and Dittmer, 1974
Chicken	White Leghorn	female	NS	98	1.10700	NS	Altman and Dittmer, 1974
Chicken	White Leghorn	female	NS	112	1.27000	NS	Altman and Dittmer, 1974
Chicken	White Leghorn	female	NS	126	1.40200	NS	Altman and Dittmer, 1974
Chicken	White Leghorn	female	NS	140	1.55100	NS	Altman and Dittmer, 1974
Chicken	White Leghorn	male	NS	1	0.03600	NS	Altman and Dittmer, 1974
Chicken	White Leghorn	male	NS	7	0.05900	NS	Altman and Dittmer, 1974
Chicken	White Leghorn	male	NS	14	0.12300	NS	Altman and Dittmer, 1974
Chicken	White Leghorn	male	NS	21	0.19100	NS	Altman and Dittmer, 1974
Chicken	White Leghorn	male	NS	28	0.26800	NS	Altman and Dittmer, 1974
Chicken	White Leghorn	male	NS	35	0.34500	NS	Altman and Dittmer, 1974
Chicken	White Leghorn	male	NS	42	0.44900	NS	Altman and Dittmer, 1974
Chicken	White Leghorn	male	NS	49	0.60300	NS	Altman and Dittmer, 1974
Chicken	White Leghorn	male	NS	56	0.68900	NS	Altman and Dittmer, 1974
Chicken	White Leghorn	male	NS	63	0.87500	NS	Altman and Dittmer, 1974
Chicken	White Leghorn	male	NS	70	0.94400	NS	Altman and Dittmer, 1974
Chicken	White Leghorn	male	NS	84	1.24300	NS	Altman and Dittmer, 1974

TABLE 3-12 (cont.)

Species	Strain	Sex	No. of Animals	Age (days)	Weight (kg)	Variance	Reference
Chicken	White Leghorn	male	NS	98	NS	NS	Altman and Dittmer, 1974
Chicken	White Leghorn	male	NS	112	NS	NS	Altman and Dittmer, 1974
Chicken	White Leghorn	male	NS	126	NS	NS	Altman and Dittmer, 1974
Chicken	White Leghorn	male	NS	140	NS	NS	Altman and Dittmer, 1974
Chicken	White Leghorn	NS	14	21	0.18300	3.24E-004	Dunson and Buss, 1968
Chicken	White Leghorn	NS	4	28	0.20000	7.29E-004	Dunson and Buss, 1968
Chicken	White Leghorn	NS	8	28	0.32000	2.56E-004	Dunson and Buss, 1968
Chicken	White Leghorn	NS	15	140	1.53200	9.42E-002	Dunson and Buss, 1968
Donkeys	NS	female	1	1825	120.00000	NS	Amoroso et al., 1964
Goats	Several	female	3	1095	52.50000	1.41E0001	Watkins et al., 1973
Horses	Equus caballus	female	1	9125	500.00000	NS	Amoroso et al., 1964
Horses	Equus caballus	male	1	2190	410.00000	NS	Amoroso et al., 1964
Horses	Equus caballus	male	1	2920	360.00000	NS	Amoroso et al., 1964
Horses	Equus caballus	male	1	4380	510.00000	NS	Amoroso et al., 1964
Horses	Equus caballus	male	1	5475	600.00000	NS	Amoroso et al., 1964
Horses	NS	NS	NS	1971	481.00000	NS	NAS, 1971
Mules	NS	male	1	4745	210.00000	NS	Amoroso et al., 1964
Pigs	Cross-bred	both	30	70	30.00000	NS	Pond et al., 1985
Pigs	Cross-bred	both	30	126	74.00000	NS	Pond et al., 1985
Pigs	Cross-bred	both	30	154	99.00000	NS	Pond et al., 1985
Pigs	Cross-bred	both	30	175	118.00000	NS	Pond et al., 1985
Pigs	Duroc-Jersey	female	NS	300	95.00000	NS	Campbell and Lasley, 1975
Pigs	Duroc-Jersey	female	NS	600	140.00000	NS	Campbell and Lasley, 1975
Pigs	Duroc-Jersey	female	NS	900	165.00000	NS	Campbell and Lasley, 1975
Pigs	Duroc-Jersey	female	NS	1200	180.00000	NS	Campbell and Lasley, 1975
Pigs	Duroc-Jersey	female	NS	1500	190.00000	NS	Campbell and Lasley, 1975
Pigs	Duroc-Jersey	female	NS	1800	195.00000	NS	Campbell and Lasley, 1975
Pigs	Duroc-Jersey	female	NS	2400	198.00000	NS	Campbell and Lasley, 1975
Pigs	NS	female	1	1	2.50000	NS	Conally, 1967
Pigs	NS	female	1	140	65.00000	NS	Conally, 1967
Pigs	NS	female	1	280	150.00000	NS	Conally, 1967
Pigs	NS	female	1	420	180.00000	NS	Conally, 1967
Pigs	NS	female	1	560	220.00000	NS	Conally, 1967

TABLE 3-12 (cont.)

Species	Strain	Sex	No. of Animals	Age (days)	Weight (kg)	Variance	Reference
Pigs	NS	NS	8	1	1.18000	1.37E-001	Clement et al., 1986
Pigs	NS	NS	15	114	30.00000	1.39E0002	Clement et al., 1986
Pigs	NS	NS	3	2	1.04700	4.23E-003	Mortola, 1983
Pigs	NS	NS	3	1	1.16700	9.42E-002	Mortola, 1984
Pigs	Sus scrofa	female	1	183	17.00000	NS	Amoroso et al., 1964
Pigs	White cross	NS	51	21	4.85000	NS	Brooks et al., 1984
Pigs	White cross	NS	51	21	5.34000	NS	Brooks et al., 1984
Pigs	White cross	NS	51	28	5.49000	NS	Brooks et al., 1984
Pigs	White cross	NS	51	28	6.15000	NS	Brooks et al., 1984
Pigs	White cross	NS	51	35	7.15000	NS	Brooks et al., 1984
Pigs	White cross	NS	51	35	7.99000	NS	Brooks et al., 1984
Pigs	White cross	NS	51	42	9.77000	NS	Brooks et al., 1984
Pigs	White cross	NS	51	42	10.60000	NS	Brooks et al., 1984
Pigs	White cross	NS	51	42	13.60000	NS	Brooks et al., 1984
Pigs	White cross	NS	51	49	13.06000	NS	Brooks et al., 1984
Sheep	NS	NS	NS	grown	31.50000	5.06E0000	Lane-Peter et al., 1967
Sheep	NS	NS	NS	grown	45.00000	2.03E0001	Lane-Peter et al., 1967
Sheep	NS	NS	NS	weaned	63.00000	2.03E0001	Lane-Peter et al., 1967
Sheep	Ovis aries	female	1	730	52.00000	NS	Amoroso et al., 1964

NS - Not specified

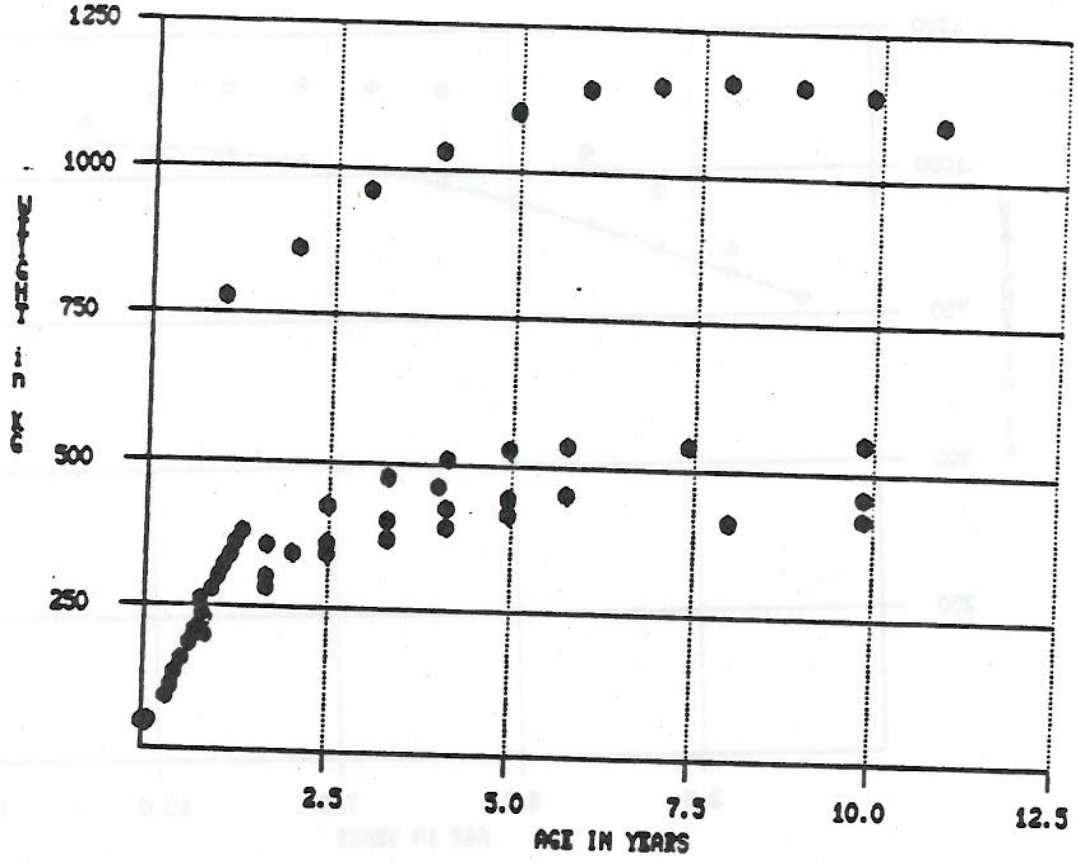


FIGURE 3-51

Growth Data on Cattle

(See Table 3-11 for points and references)

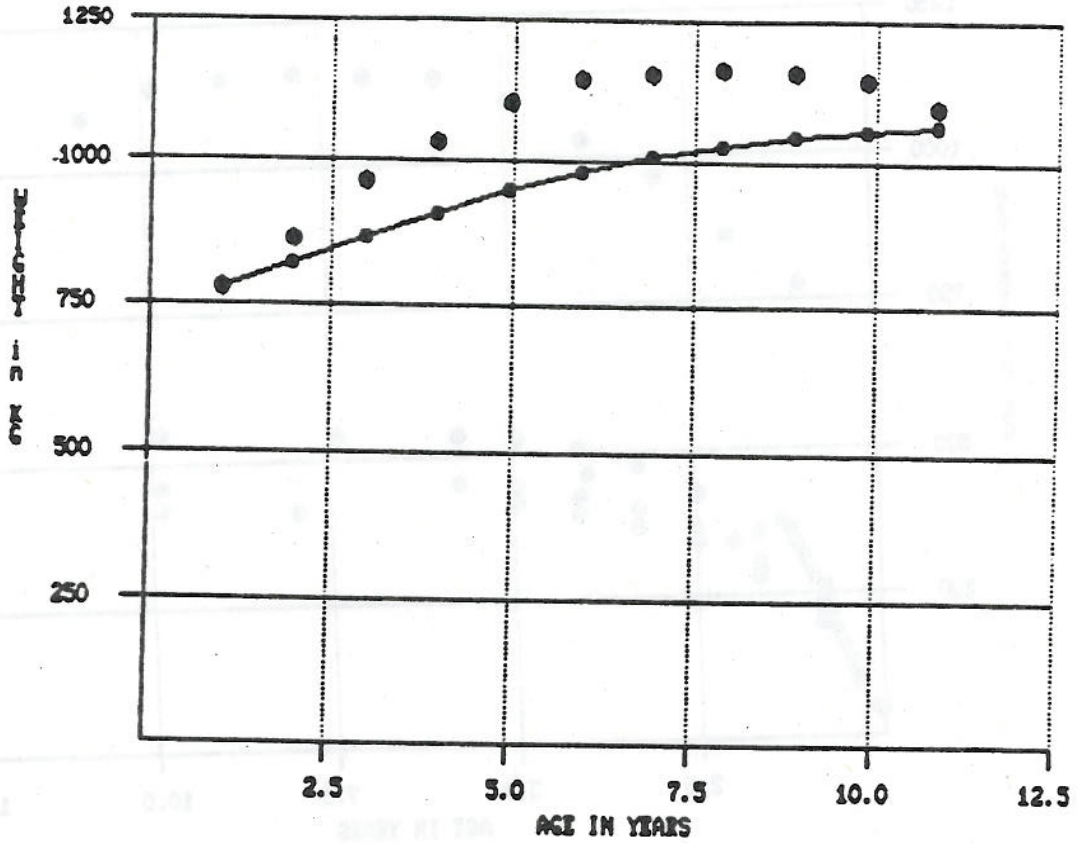


FIGURE 3-52

Growth Curve on Female Hereford Cattle

(See Table 3-12 for points and references)

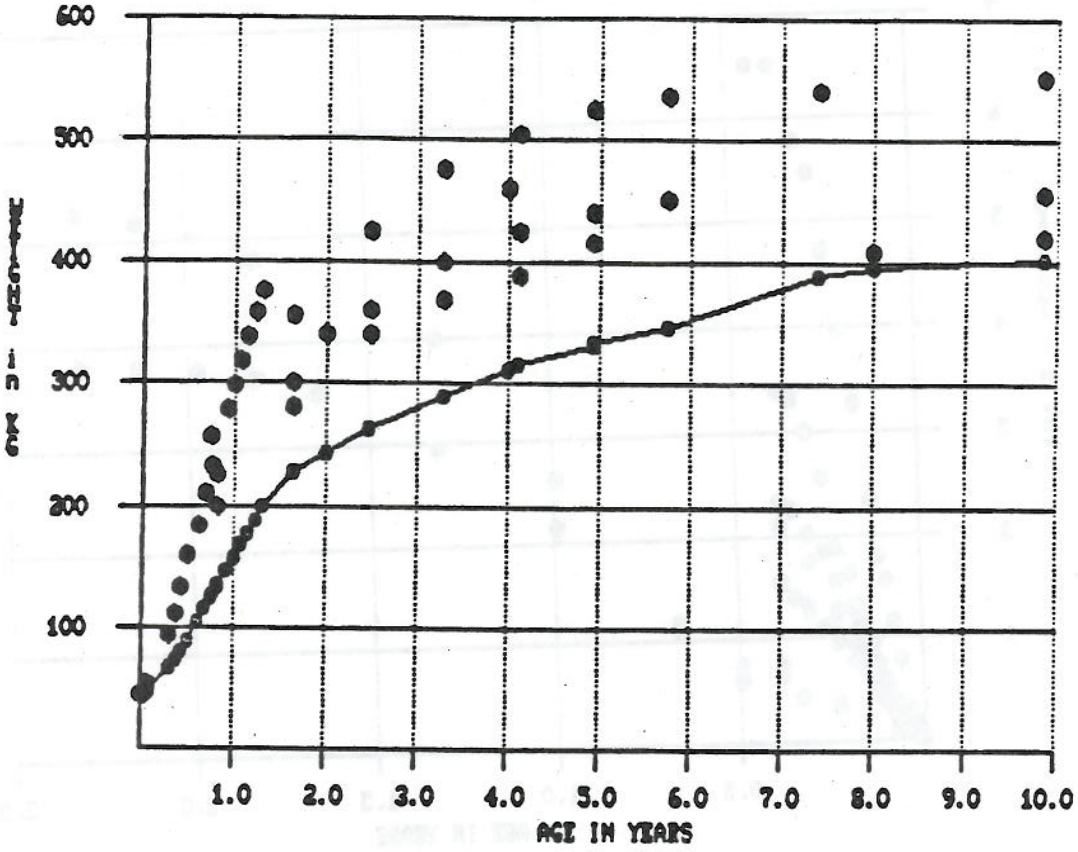


FIGURE 3-53

Growth Curve on Cattle, Excluding Female Hereford Cattle

(See Table 3-12 for points and references)

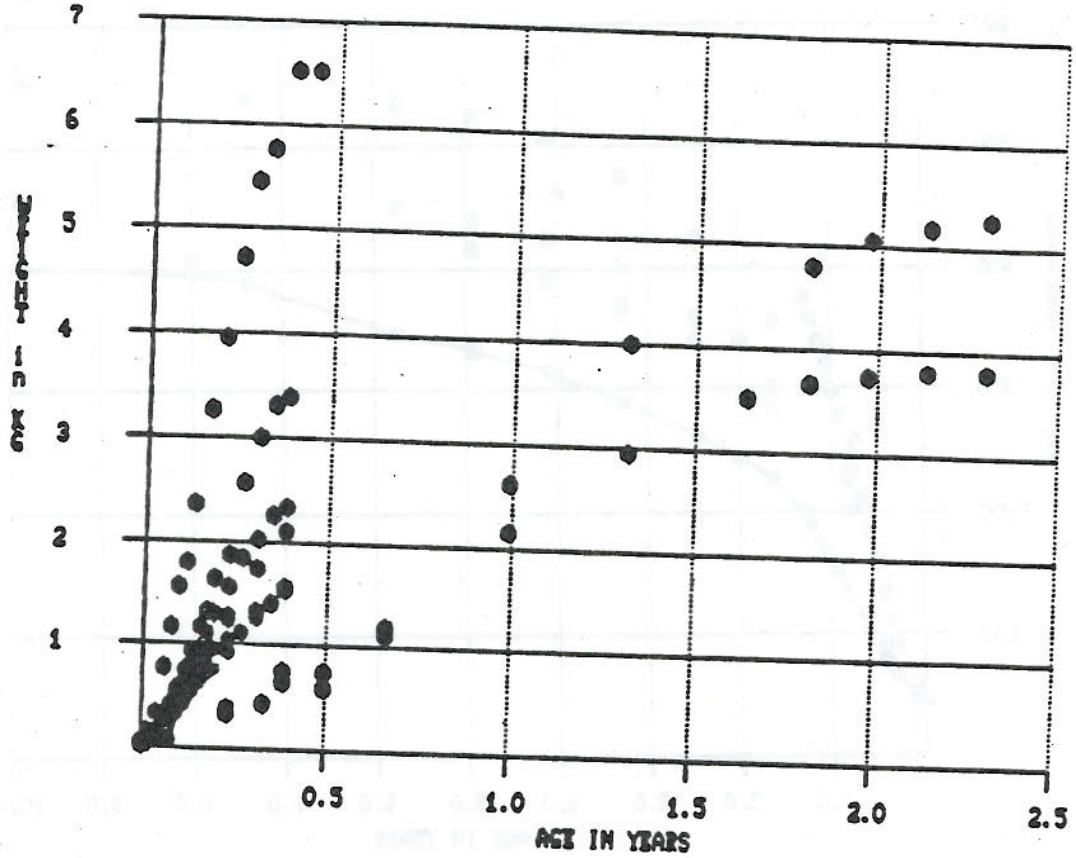


FIGURE 3-54

Growth Data on Chickens

(See Table 3-12 for points and references)

Chickens, particularly the White Leghorn, have been used as animal models for studying peripheral neurotoxins. Growth data on male and female White Leghorns are presented in Figures 3-55 and 3-56. Because bioassays using chickens are not well standardized, no attempt will be made to recommend subchronic or chronic body weights. Depending on the nature of the experiment, the data in Table 3-12 and Figures 3-55 or 3-56 could be used to estimate the most appropriate body weight.

3.4.3. Pigs. All growth data from Table 3-12 on pigs are plotted in Figure 3-57. The growth data reported by Pond et al. (1985) and Conalty (1967), plotted in Figure 3-58, are consistent with each other but show substantially more rapid growth than other reports on the domestic pig (Sus domesticus). Data from these latter reports are plotted in Figure 3-59. The data reported by Amoroso et al. (1964) are for the miniature pig, Sus scrofa, and are not likely to be typical of swine used as livestock. Recommended mature body weights for livestock swine (Sus domesticus) are 200-250 kg. Based on Figures 3-58 and 3-59, other body weight estimates for swine can be derived as needed.

3.5. WILDLIFE

Growth data on wildlife are summarized in Table 3-13. As discussed by Moody et al. (1985) for ferrets and Zatzman et al. (1984) for marmots, many species of wildlife mammals show substantial (30-40%) seasonal variation in body weight. Such seasonal variations are also likely to be seen in livestock and laboratory animals, but are less well documented.

Figures 3-60 and 3-61 summarize the body weights of male and female mink from two control groups used by Aulerich et al. (1979) in a study on the toxicity of PCBs, a compound to which mink are particularly susceptible.

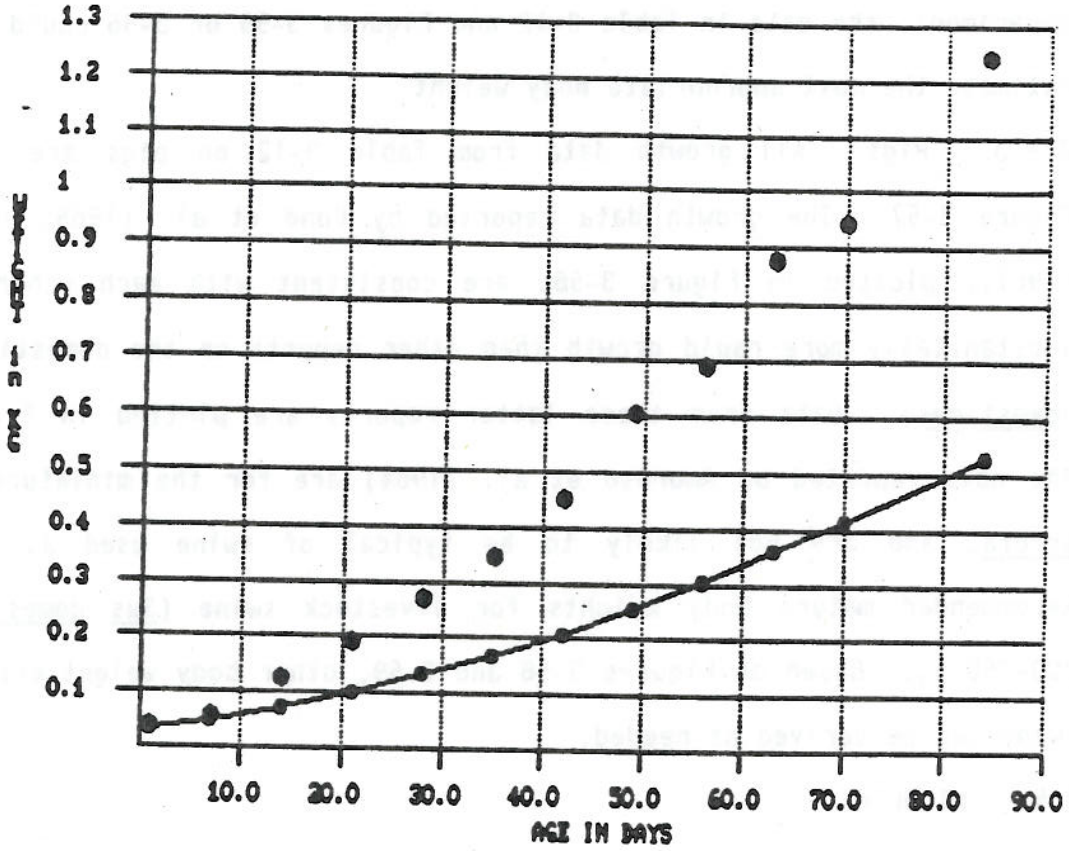


FIGURE 3-55

Growth Data on Male White Leghorn Chickens

(See Table 3-12 for points and references)

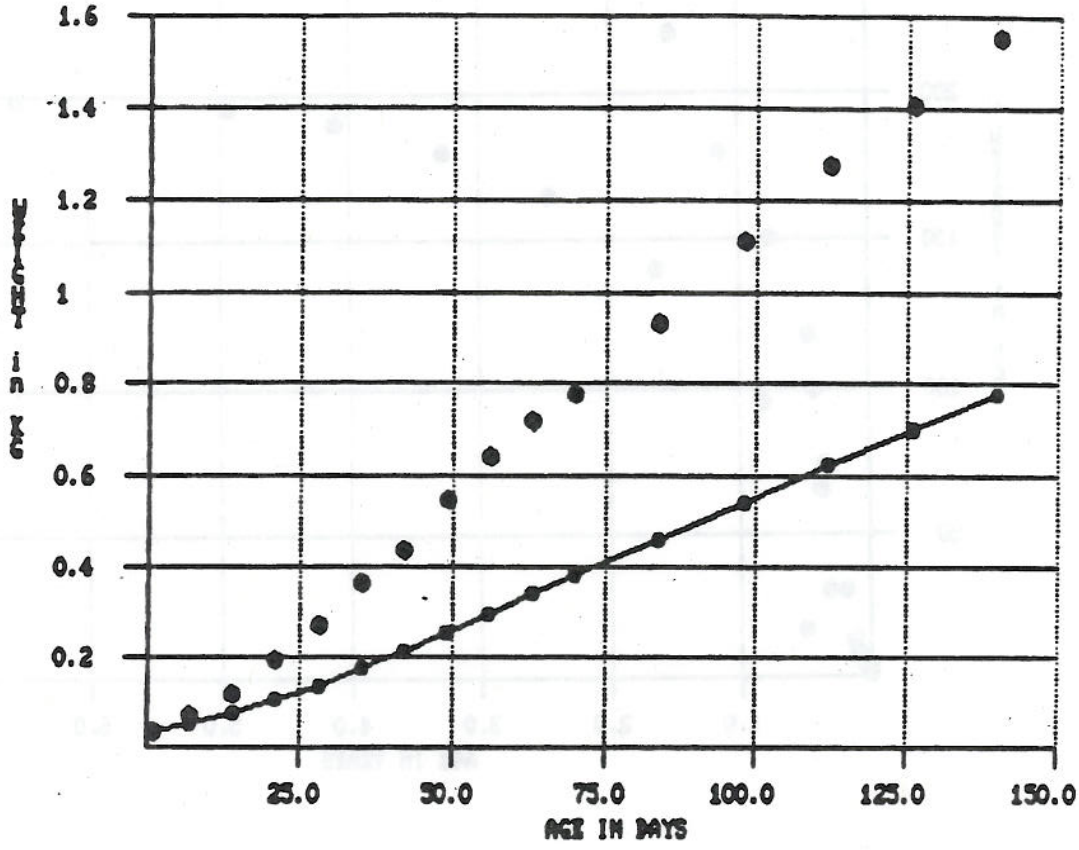


FIGURE 3-56

Growth Data on Female White Leghorn Chickens

(See Table 3-12 for points and references)

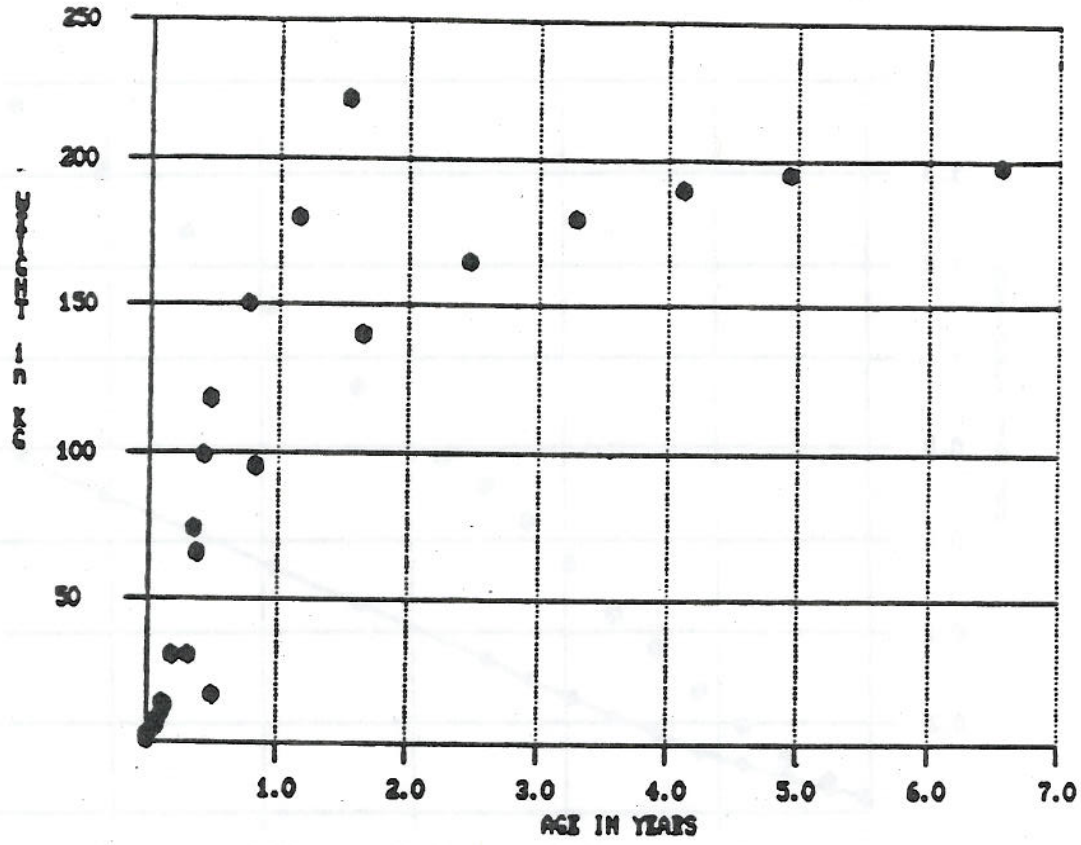


FIGURE 3-57

Growth Data on Domestic and Miniature Pigs

(See Table 3-12 for points and references)

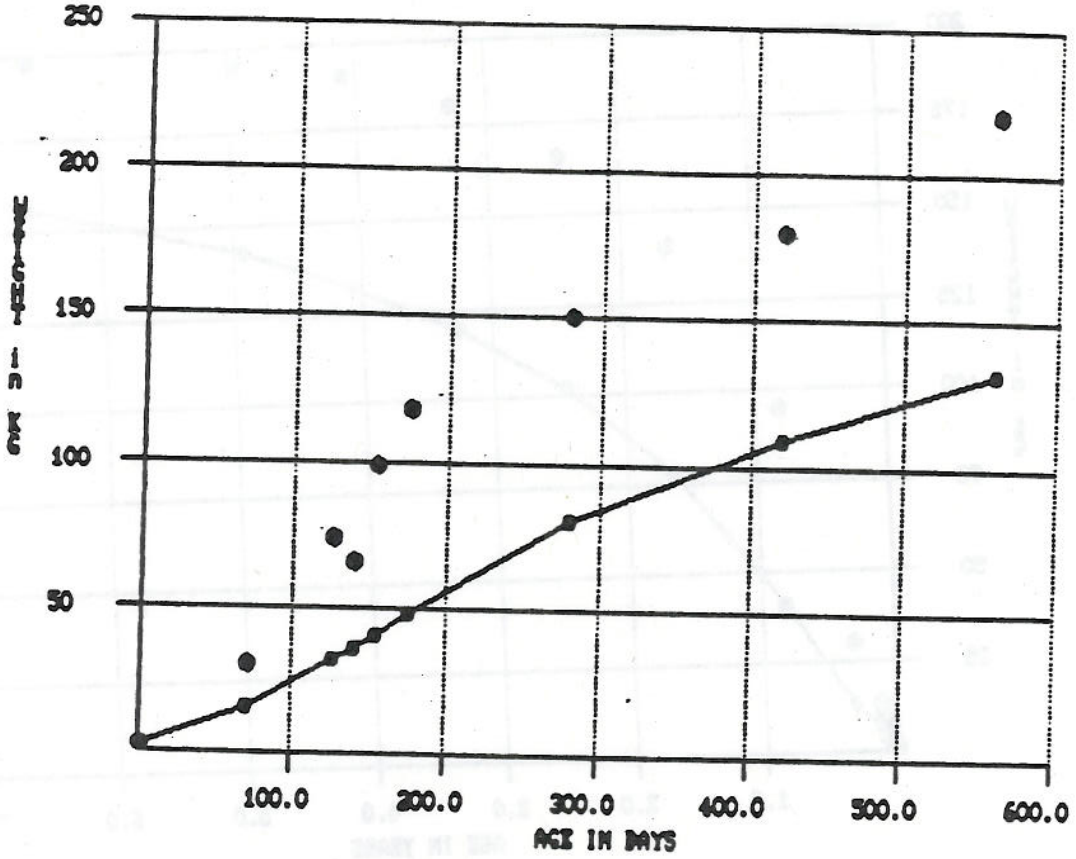


FIGURE 3-58

Growth Data on Larger Domestic Pigs

[Data from Pond et al. (1985) and Conalty (1967)]

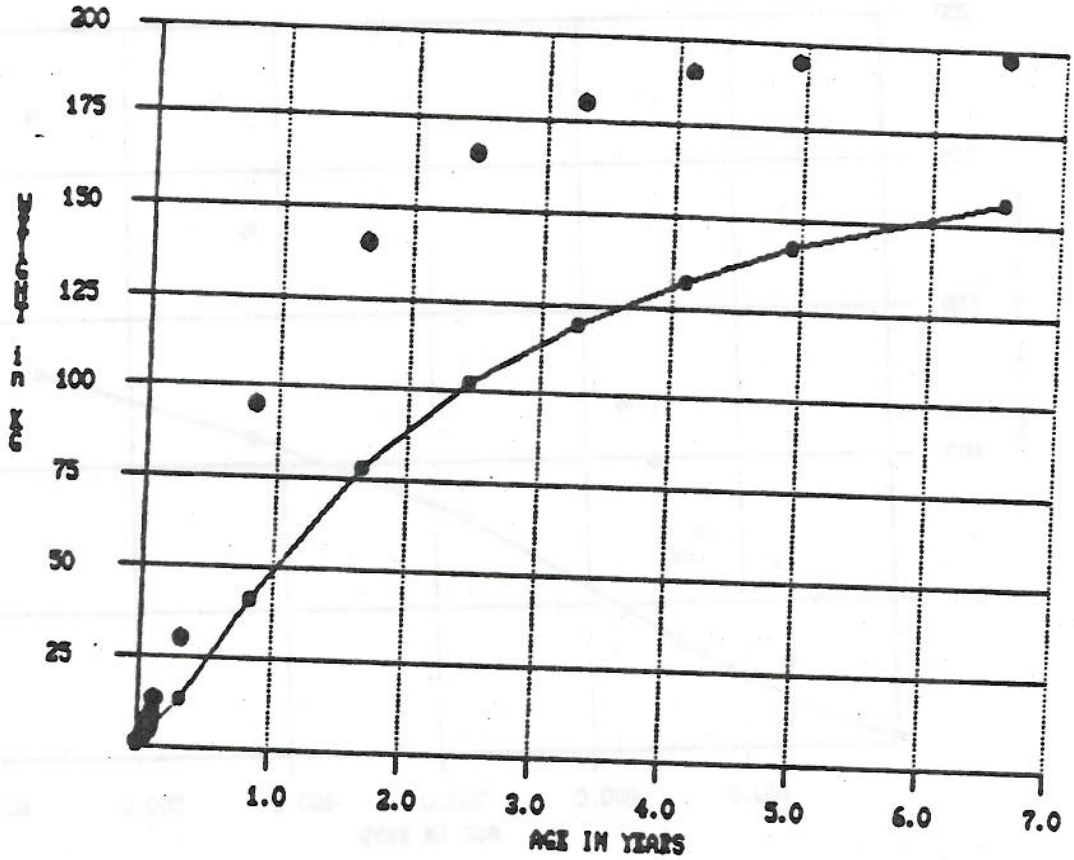


FIGURE 3-59

Growth Data on Smaller Domestic Pigs

(See Table 3-12 for points and references)

TABLE 3-13

Growth and Body Weight Data on Wildlife

Species/Strain	Sex	No. of Animals	Age (days)	Weight (kg)	Variance	Reference
Ferrets/domestic	female	NS	adult	0.67500	1.27E-002	Moody et al., 1985
Ferrets/domestic	male	NS	adult	2.02500	1.14E-001	Moody et al., 1985
Ferrets/NS	male	9	young	0.71150	6.28E-003	Vinegar et al., 1985
Marmots/yellow-bellied	female	9	adult	3.81000	5.76E-002	Zatzman et al., 1984
Marmots/yellow-bellied	female	9	adult	3.86000	5.76E-002	Zatzman et al., 1984
Marmots/yellow-bellied	male	9	adult	4.62000	2.81E-001	Zatzman et al., 1984
Marmots/yellow-bellied	male	9	adult	4.76000	2.92E-001	Zatzman et al., 1984
Marmots/yellow-bellied	male	9	adult	4.95000	3.03E-001	Zatzman et al., 1984
Marmots/yellow-bellied	male	9	adult	5.19000	3.48E-001	Zatzman et al., 1984
Marmots/yellow-bellied	male	9	adult	5.29000	4.36E-001	Zatzman et al., 1984
Marmots/yellow-bellied	male	9	adult	5.32000	3.97E-001	Zatzman et al., 1984
Marmots/yellow-bellied	male	9	adult	5.33000	4.23E-001	Zatzman et al., 1984
Marmots/yellow-bellied	male	9	adult	5.39000	3.72E-001	Zatzman et al., 1984
Marmots/yellow-bellied	male	9	adult	5.45000	4.10E-001	Zatzman et al., 1984
Marmots/yellow-bellied	male	9	adult	5.46000	4.62E-001	Zatzman et al., 1984
Marmots/yellow-bellied	male	9	adult	5.50000	4.49E-001	Zatzman et al., 1984
Mink/NS	female	24	90	0.75000	NS	Aulerich et al., 1979
Mink/NS	female	24	90	0.76000	NS	Aulerich et al., 1979
Mink/NS	female	24	103	0.86100	NS	Aulerich et al., 1979
Mink/NS	female	24	103	0.87600	NS	Aulerich et al., 1979
Mink/NS	female	24	118	0.91900	NS	Aulerich et al., 1979
Mink/NS	female	24	118	0.93400	NS	Aulerich et al., 1979
Mink/NS	female	24	132	0.92000	NS	Aulerich et al., 1979
Mink/NS	female	24	132	0.95500	1.11E-002	Aulerich et al., 1979
Mink/NS	female	24	146	0.97100	NS	Aulerich et al., 1979
Mink/NS	female	24	146	0.98400	1.53E-002	Aulerich et al., 1979

TABLE 3-13 (cont.)

Species/Strain	Sex	No. of Animals	Age (days)	Weight (kg)	Variance	Reference
Mink/NS	female	24	160	0.99900	NS	Aulerich et al., 1979
Mink/NS	female	24	160	1.03900	1.57E-002	Aulerich et al., 1979
Mink/NS	female	24	174	1.04100	NS	Aulerich et al., 1979
Mink/NS	female	24	174	1.06600	2.70E-002	Aulerich et al., 1979
Mink/NS	female	24	188	1.03100	NS	Aulerich et al., 1979
Mink/NS	female	24	188	1.06500	1.25E-002	Aulerich et al., 1979
Mink/NS	female	24	202	1.02000	NS	Aulerich et al., 1979
Mink/NS	female	24	202	1.05800	1.88E-002	Aulerich et al., 1979
Mink/NS	female	24	214	1.01400	NS	Aulerich et al., 1979
Mink/NS	female	24	214	1.04100	2.31E-002	Aulerich et al., 1979
Mink/NS	female	24	230	0.93700	NS	Aulerich et al., 1979
Mink/NS	female	24	230	0.96800	1.80E-002	Aulerich et al., 1979
Mink/NS	female	24	245	0.98900	NS	Aulerich et al., 1979
Mink/NS	female	24	245	1.01800	3.14E-003	Aulerich et al., 1979
Mink/NS	female	24	261	0.92700	NS	Aulerich et al., 1979
Mink/NS	female	24	261	0.97000	1.15E-002	Aulerich et al., 1979
Mink/NS	female	24	275	0.93300	NS	Aulerich et al., 1979
Mink/NS	female	24	275	0.96200	1.49E-002	Aulerich et al., 1979
Mink/NS	female	24	292	0.90900	NS	Aulerich et al., 1979
Mink/NS	female	24	292	0.94100	8.06E-003	Aulerich et al., 1979
Mink/NS	female	24	306	0.93600	NS	Aulerich et al., 1979
Mink/NS	female	24	306	0.96800	2.46E-002	Aulerich et al., 1979
Mink/NS	female	24	320	0.94700	NS	Aulerich et al., 1979
Mink/NS	female	24	320	0.96500	2.42E-003	Aulerich et al., 1979
Mink/NS	female	24	438	0.81100	NS	Aulerich et al.,1979
Mink/NS	female	24	438	0.82100	5.89E-003	Aulerich et al., 1979
Mink/NS	male	6	90	1.08300	4.39E-002	Aulerich et al., 1979
Mink/NS	male	5	90	1.13700	NS	Aulerich et al., 1979
Mink/NS	male	6	103	1.29700	3.48E-002	Aulerich et al., 1979

TABLE 3-13 (cont.)

Species/Strain	Sex	No. of Animals	Age (days)	Weight (kg)	Variance	Reference
Mink/NS	male	5	103	1.33900	NS	Aulerich et al., 1979
Mink/NS	male	5	118	1.37800	NS	Aulerich et al., 1979
Mink/NS	male	6	118	1.42700	5.71E-002	Aulerich et al., 1979
Mink/NS	male	5	132	1.56900	NS	Aulerich et al., 1979
Mink/NS	male	6	132	1.56900	2.27E-002	Aulerich et al., 1979
Mink/NS	male	5	146	1.59100	NS	Aulerich et al., 1979
Mink/NS	male	6	146	1.63100	3.60E-003	Aulerich et al., 1979
Mink/NS	male	6	160	1.64900	3.97E-003	Aulerich et al., 1979
Mink/NS	male	5	160	1.66900	NS	Aulerich et al., 1979
Mink/NS	male	6	174	1.65400	1.44E-003	Aulerich et al., 1979
Mink/NS	male	5	174	1.68600	NS	Aulerich et al., 1979
Mink/NS	male	6	188	1.68000	1.37E-003	Aulerich et al., 1979
Mink/NS	male	5	188	1.71000	NS	Aulerich et al., 1979
Mink/NS	male	6	202	1.76600	1.02E-003	Aulerich et al., 1979
Mink/NS	male	5	202	1.78100	NS	Aulerich et al., 1979
Mink/NS	male	6	214	1.73100	1.09E-003	Aulerich et al., 1979
Mink/NS	male	5	214	1.73200	NS	Aulerich et al., 1979
Mink/NS	male	5	230	1.56400	NS	Aulerich et al., 1979
Mink/NS	male	6	230	1.61300	1.76E-003	Aulerich et al., 1979
Mink/NS	male	5	245	1.59600	NS	Aulerich et al., 1979
Mink/NS	male	6	245	1.64900	NS	Aulerich et al., 1979
Mink/NS	male	5	261	1.48300	NS	Aulerich et al., 1979
Mink/NS	male	6	261	1.53500	NS	Aulerich et al., 1979
Mink/NS	male	5	275	1.47600	NS	Aulerich et al., 1979
Mink/NS	male	6	275	1.55300	NS	Aulerich et al., 1979
Mink/NS	male	5	292	1.49600	NS	Aulerich et al., 1979
Mink/NS	male	6	292	1.59100	NS	Aulerich et al., 1979
Mink/NS	male	5	306	1.60700	NS	Aulerich et al., 1979
Mink/NS	male	6	306	1.66900	NS	Aulerich et al., 1979
Mink/NS	male	5	320	1.59500	NS	Aulerich et al., 1979

TABLE 3-13 (cont.)

Species/Strain	Sex	No. of Animals	Age (days)	Weight (kg)	Variance	Reference
Mink/NS	male	6	320	1.67200	NS	Aulerich et al., 1979
Mink/NS	male	6	438	1.64000	NS	Aulerich et al., 1979
Mink/NS	male	5	438	1.69200	NS	Aulerich et al., 1979
Mink/NS	both	NS	1	0.00930	NS	Aulerich et al., 1979
Mink/NS	both	NS	1	0.00962	NS	Aulerich et al., 1979
Mink/NS	both	NS	28	0.15760	NS	Aulerich et al., 1979
Mink/NS	both	NS	28	0.16500	NS	Aulerich et al., 1979
Voles/meadow	both	28	176	0.04100	5.62E-005	Lee and Horvath, 1969
Voles/meadow	NS	7	45	0.04500	5.62E-005	Laughlin et al., 1975
Voles/NS	NS	NS	NS	0.04100	NS	NAS, 1978

NS = Not specified

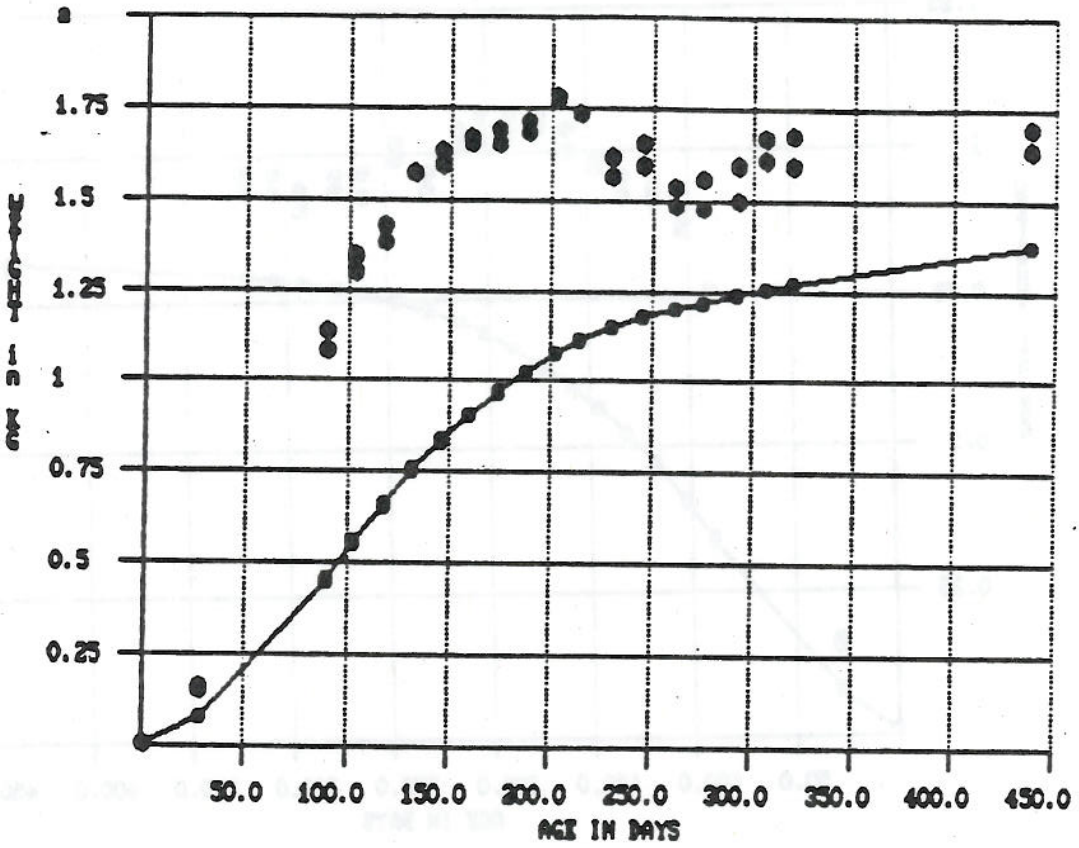


FIGURE 3-60

Recommended Growth Curve for Male Mink
(See Table 3-13 for points and references)

Source: Aulerich et al., 1979

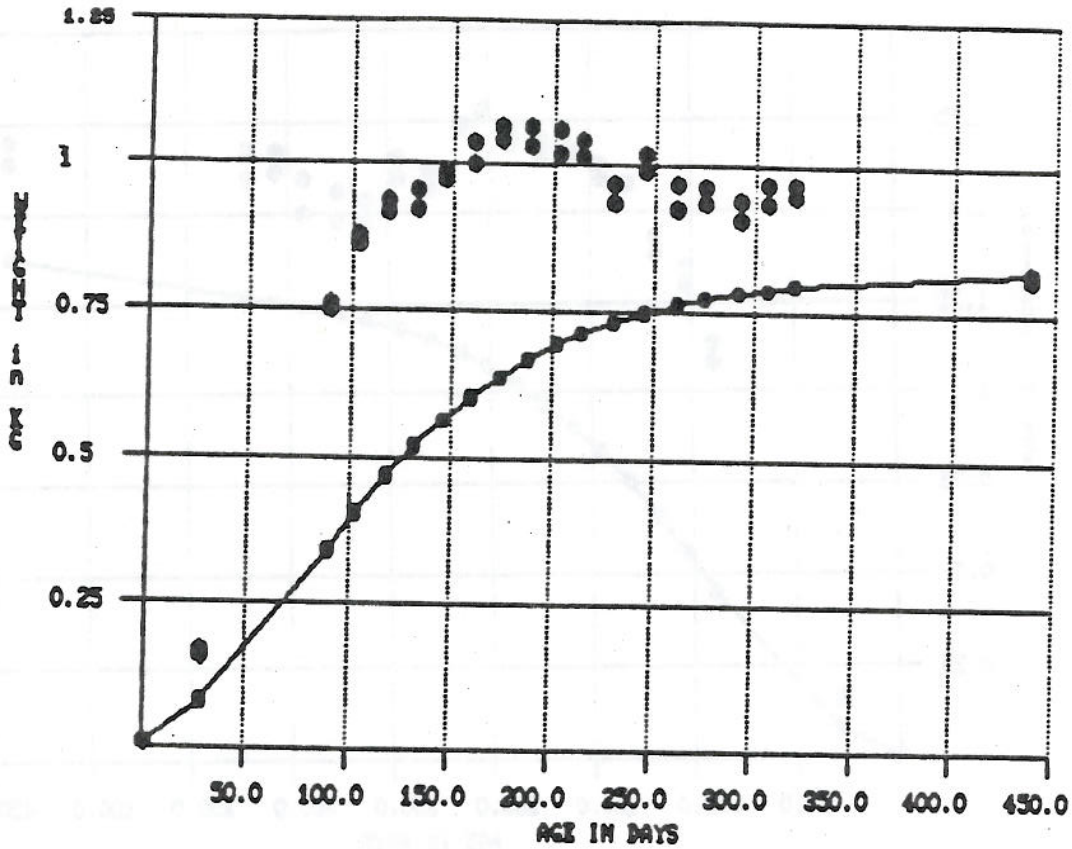


FIGURE 3-61

Recommended Growth Curve for Female Mink
(See Table 3-13 for points and references)

Source: Aulerich et al., 1979

The variations in the weight of both sexes during the last 250 days of the study suggest a seasonal effect. While Figures 3-60 and 3-61 can be used to estimate recommended body weights for young and mature animals, the seasonal effects should be appreciated as a source of error, particularly in these and other wildlife species.

Since bioassays on mink are not standardized in duration, reference subchronic and chronic body weights are not recommended. TWA body weights can be calculated from Figures 3-60 and 3-61. These curves can be extended using recommended mature body weights of 1.7 kg for males and 1.0 kg for females.

4. INHALATION RATES

The U.S. EPA (1980) has recommended the use of a reference value of 20 m^3/day for humans (10 m^3 breathing volume during the workday). The inhalation rate for the ICRP Reference Man is 23 m^3/day (9.6 m^3 breathing volume at work during light activity). Other recommended values are 21 m^3/day for an adult woman, 15 m^3/day for a 10-year-old child, 3.8 m^3/day for a 1-year-old infant and 0.8 m^3/day for a newborn (Snyder et al., 1975).

Minute volumes for the reference man resting and performing light activity are 7.5 and 20 ℓ/minute, respectively. The reference minute volume for light activity is reasonably close to the reported values for adult humans given in Table 4-1. Assuming that man rests for 8 hours and is involved in light activity for 16 hours each day, the resting minute volume can be multiplied by a factor of 2.1 to approximate a TWA minute volume over an entire day [((7.5x8hr)+(20x16hr))/24hr)/7.5=2.11]. Unless this activity factor is used on the human data, the allometric equations discussed in this section substantially underestimate human breathing volumes for adolescents and adults. Rigorous evaluation of human values is outside the scope of this text. Additional information is provided in U.S. EPA (1985a). Since the minute volumes reported in the literature for experimental mammals and other animals were made when the animals were at rest and not under conditions of normal activity, a similar activity factor could be proposed for these species. This factor is not applied to the allometric equations for nonhuman animals because in most toxicity studies the activity of the animals is restricted by confinement. The use of upper or lower bounds of the allometric equations should be considered if hyperactivity or lethargy is reported. In some instances in which the exposed dose must be estimated

TABLE 4-1

Inhalation Data on Various Animal Groups

Group	Species	Strain	Sex	No. of Animals	Age (days)	Weight (kg)	Minute Volume (ℓ)	Reference
Primates	human		M&F	4	12,593	NS	5.40	Maxwell et al., 1985
	human		M&F	6	12,593	NS	5.90	Maxwell et al., 1985
	human		M&F	8	12,593	NS	5.90	Maxwell et al., 1985
	human		M&F	21	17,885	74.0	7.70	White et al., 1985
	human		F	20	6.6	3.420	0.57090	Cross, 1949
	human		F	29	9,855	64.150	8.0	Aitken et al., 1986
	human		M	16	5	3.670	0.61240	Cross, 1949
	human		M	37	9,855	94.550	9.80	Aitken et al., 1986
	human		NS	15	8	NS	0.690	Haddad et al., 1979
	human		NS	15	35	NS	0.810	Haddad et al., 1979
	human		NS	15	63	NS	1.080	Haddad et al., 1979
	human		NS	22	<1	3.40	1.3930	Fisher et al., 1982
	human		NS	12	<1	3.50	1.4110	Fisher et al., 1982
	human		NS	10	NS	NS	1.41230	Fisher et al., 1982
	human		NS	10	NS	NS	1.41230	Fisher et al., 1982
	human		NS	15	91	NS	1.440	Haddad et al., 1979
	human		NS	23	<1	3.430	1.4920	Fisher et al., 1982
	human		NS	15	120	NS	1.530	Haddad et al., 1979
	human		NS	8	NS	NS	1.57730	Fisher et al., 1982
	human		NS	4	<1	3.470	1.9830	Fisher et al., 1982
	human		NS	NS	NS	70	7.50	Hugh-Jones et al., 1978
	human		NS	6	NS	68.50	8.730	Guyton, 1947
	monkey	rhesus	M&F	39	NS	2.630	1.0140	Karel and Weston, 1946
	monkey	rhesus	M	4	NS	4.050	1.120	Liu and DeLauter, 1977
	monkey	rhesus	M	4	NS	4.050	1.120	Liu and DeLauter, 1977
	monkey	rhesus	NS	NS	NS	2.680	0.860	Lumb, 1963
	monkey		NS	6	NS	2.680	0.8630	Guyton, 1947
Laboratory rodents	guinea pig	Hartley	M&F	10	98	0.5120	0.1710	Mauderly et al., 1979
	guinea pig	Hartley, C.R.	F	6	NS	0.32550	0.0790	Horike et al., 1982
	guinea pig	Hartley, C.R.	F	10	NS	0.32550	0.1040	Horike et al., 1982
	guinea pig	Hartley, large	M	10	NS	0.8170	0.4040	Blake and Banchero, 1985
	guinea pig	Hartley, small	M	5	NS	0.2690	0.2530	Blake and Banchero, 1985
	guinea pig	Hartley	M	36	NS	0.350	0.24970	Skornik et al., 1981
	guinea pig		M	6	NS	0.340	0.220	Murphy and Ulrich, 1964
	guinea pig		M	6	NS	0.3090	0.25450	Murphy and Ulrich, 1964
	guinea pig		M	6	NS	0.3790	0.26460	Murphy and Ulrich, 1964
	guinea pig		NS	2	3	0.09110	0.07610	Mortola, 1984
	guinea pig		NS	200	NS	0.2190	0.1390	Amdur and Mead, 1958
	guinea pig		NS	49	NS	0.4770	0.1540	Guyton, 1947
	guinea pig		NS	61	NS	0.4660	0.1560	Guyton, 1947
	guinea pig		NS	NS	NS	0.4710	0.160	Lumb, 1963
	guinea pig		NS	8	NS	0.1940	0.1620	Mead, 1960

TABLE 4-1 (cont.)

Group	Species	Strain	Sex	No. of Animals	Age (days)	Weight (kg)	Minute Volume (ℓ)	Reference
Laboratory rodents (cont.)	hamster	Syrian[Sch:Syr]	M&F	10	98	0.110	0.050	Mauderly et al., 1979
	hamster	Syrian	M&F	10	112	0.1110	0.050	Mauderly and Tesarek, 1975
	hamster	Djungarian	M	12	NS	0.03240	0.02240	Schlenker, 1985
	hamster	golden	M	10	NS	0.11540	0.04202	Holloway and Heath, 1984
	hamster	golden	M	16	NS	0.110	0.07090	Javaheri and Lucey, 1986
	hamster	Syrian F1B	M	10	NS	0.06380	0.03450	Schlenker, 1984
	hamster	Syrian F1B	M	10	NS	0.08860	0.04050	Schlenker, 1984
	hamster	Syrian F1B	M	10	NS	0.1020	0.0420	Schlenker, 1984
	hamster	Syrian	M	8	NS	0.1080	0.02930	Strope et al., 1980
	hamster	Syrian	M	7	NS	0.1420	0.05041	Walker et al., 1985
	hamster	Syrian	M	40	105	0.1290	0.0710	Rubin et al., 1978
	hamster	white	M	4	NS	0.090	0.030	Chapin, 1955
	hamster	white	M	4	NS	0.10	0.0330	Chapin, 1955
	hamster	white	M	4	NS	0.130	0.0420	Chapin, 1955
	hamster		NS	4	5	0.00643	0.00298	Mortola and Noworaj, 1985
	hamster		NS	NS	NS	0.0910	0.050	Lumb, 1963
	hamster		NS	65	NS	0.0920	0.0610	Guyton, 1947
	mice		NS	5	2.8	0.00250	0.00230	Mortola, 1984
	mice		NS	56	NS	0.020	0.0240	Guyton, 1947
	mouse	CBA Ca Lac Cb1	M	1	NS	0.02370	0.02090	DePledge, 1985
	mouse	CBA Ca Lac Cb1	M	1	NS	0.02190	0.02190	DePledge, 1985
	mouse	CBA Ca Lac Cb1	M	1	NS	0.02450	0.02190	DePledge, 1985
	mouse	CBA Ca Lac Cb1	M	1	NS	0.02660	0.02820	DePledge, 1985
	mouse	CBA Ca Lac Cb1	M	1	NS	0.03130	0.03050	DePledge, 1985
	mouse	CBA Ca Lac Cb1	M	1	NS	0.02690	0.03160	DePledge, 1985
	mouse	CBA Ca Lac Cb1	M	1	NS	0.03310	0.03430	DePledge, 1985
	mouse	CBA Ca Lac Cb1	M	1	NS	0.03550	0.04170	DePledge, 1985
	mouse	CBA Ca Lac Cb1	M	1	NS	0.03890	0.04950	DePledge, 1985
	mouse	CBA	M	10	20	0.0080	0.01450	Criborn, 1969
	mouse	CBA	M	10	31	0.0140	0.0160	Criborn, 1969
	mouse	CBA	M	10	51	0.02450	0.0220	Criborn, 1969
	mouse	CBA	M	10	91	0.02450	0.02950	Criborn, 1969
	mouse	CD-1	M	19	37	0.02620	0.03799	Fairchild, 1972
	mouse	CD-1	M	9	55.5	0.03130	0.05039	Fairchild, 1972
	mouse	CD-1	M	10	74	0.03740	0.06769	Fairchild, 1972
	mouse	HA/ICR	M	8	90	0.03380	0.03617	Fairchild, 1972
	mouse	HA/ICR	M	8	69	0.02990	0.05083	Fairchild, 1972
	mouse	SwissWebLAI/COX	M	10	NS	0.03040	0.04880	Schlenker, 1985
	mouse		NS	NS	NS	0.01980	0.0230	Lumb, 1963

TABLE 4-1 (cont.)

Group	Species	Strain	Sex	No. of Animals	Age (days)	Weight (kg)	Minute Volume (ℓ)	Reference
Laboratory rodents (cont.)	rat	F344/Crl Lov	M&F	20	365	0.2930	0.1950	Mauderly, 1986
	rat	F344/Crl Lov	M&F	20	183	0.2670	0.2380	Mauderly, 1986
	rat	F344/Crl Lov	M&F	20	91	0.1820	0.240	Mauderly, 1986
	rat	F344/Crl Lov	M&F	20	730	0.3310	0.2590	Mauderly, 1986
	rat	Long-Evans	M&F	10	98	NS	0.2150	Mauderly, 1986
	rat	Fisher	F	32	NS	0.2330	0.1610	Diamond and O'Donnell, 1977
	rat	F334/Crl Lov	F	10	365	0.2190	0.1540	Mauderly, 1986
	rat	F334/Crl Lov	F	10	183	0.1990	0.1810	Mauderly, 1986
	rat	F334/Crl Lov	F	10	91	0.1450	0.2160	Mauderly, 1986
	rat	F334/Crl Lov	F	10	730	0.2550	0.2540	Mauderly, 1986
	rat	F344	F	20	77	0.14610	0.14430	Dorato et al., 1983
	rat	F344	F	19	91	0.15790	0.1470	Dorato et al., 1983
	rat	F344	F	19	238	0.1940	0.15390	Dorato et al., 1983
	rat	F344	F	19	161	0.180	0.15540	Dorato et al., 1983
	rat	F344	F	19	280	0.20140	0.15590	Dorato et al., 1983
	rat	F344	F	19	322	0.20690	0.15840	Dorato et al., 1983
	rat	F344	F	19	112	0.16670	0.1590	Dorato et al., 1983
	rat	F344	F	19	196	0.19080	0.16720	Dorato et al., 1983
	rat	Sprague-Dawley	F	11	NS	0.2510	0.1750	Cummings and Heitcamp, 1981
	rat	Wistar, Charles	F	12	97	NS	0.09820	Martin-Body and Sinclair, 1985
	rat	Wistar, Charles	F	12	99	NS	0.1930	Martin-Body and Sinclair, 1985
	rat	F344/Crl Lov	M	10	365	0.3680	0.2360	Mauderly, 1986
	rat	F344/Crl Lov	M	10	91	0.2910	0.2640	Mauderly, 1986
	rat	F344/Crl Lov	M	10	730	0.4070	0.2640	Mauderly, 1986
	rat	F344/Crl Lov	M	10	183	0.3360	0.2920	Mauderly, 1986
	rat	F344	M	20	77	0.21840	0.16140	Dorato et al., 1983
	rat	F344	M	20	91	0.24850	0.18610	Dorato et al., 1983
	rat	F344	M	20	280	0.38880	0.19110	Dorato et al., 1983
	rat	F344	M	20	238	0.36630	0.1920	Dorato et al., 1983
	rat	F344	M	20	322	0.40950	0.20040	Dorato et al., 1983
	rat	F344	M	20	112	0.27980	0.20130	Dorato et al., 1983
	rat	F344	M	20	161	0.31780	0.20380	Dorato et al., 1983
	rat	F344	M	20	196	0.34280	0.21550	Dorato et al., 1983
	rat	Sprague-Dawley	M	19	NS	0.40	0.1450	Bowen and Carpenter, 1979
	rat	Sprague-Dawley	M	19	NS	0.40	0.1450	Bowen and Carpenter, 1979
	rat	Sprague-Dawley	M	NS	NS	0.40	0.1450	Bowen et al., 1979
	rat	Sprague-Dawley	M	5	NS	NS	0.1540	Johanson and Pierce, 1971
	rat	Sprague-Dawley	M	5	NS	NS	0.1540	Johanson and Pierce, 1971
	rat	Sprague-Dawley	M	12	NS	NS	0.1750	Johanson and Pierce, 1971
	rat	Sprague-Dawley	M	8	NS	0.3060	0.19030	Lai et al., 1978
	rat	Sprague-Dawley	M	5	NS	0.4350	0.20611	Holloway and Heath, 1984
	rat	Sprague-Dawley	M	8	NS	0.3050	0.21380	Lai et al., 1978
	rat	Sprague-Dawley	M	8	NS	0.3050	0.2150	Lai et al., 1978

TABLE 4-1 (cont.)

Group	Species	Strain	Sex	No. of Animals	Age (days)	Weight (kg)	Minute Volume (ℓ)	Reference
Laboratory rodents (cont.)	rat	Sprague-Dawley	M	16	NS	0.4250	0.2390	Bartlett and Tennet, 1970
	rat	Sprague-Dawley	M	8	NS	0.2840	0.27580	Lai et al., 1978
	rat	Sprague-Dawley	M	8	NS	0.2910	0.45950	Lai et al., 1978
	rat	Wistar	M	10	35	0.05230	0.08690	Leong et al., 1964
	rat	Wistar	M	10	49	0.10980	0.11290	Leong et al., 1964
	rat	Wistar	M	10	70	0.21130	0.16150	Leong et al., 1964
	rat	Wistar	M	6	NS	0.30	0.17220	Walker et al., 1985
	rat	Wistar	M	10	126	0.29850	0.22490	Leong et al., 1964
	rat	cotton	NS	27	NS	0.0770	0.040	Guyton, 1947
	rat	cotton	NS	NS	NS	0.0770	0.040	Lumb, 1963
	rat	white	NS	35	NS	0.1130	0.0730	Guyton, 1947
	rat	white	NS	NS	NS	0.1120	0.0740	Lumb, 1963
	rat	white	NS	32	NS	0.110	0.0760	Guyton, 1947
	rat		NS	4	2	0.00720	0.00660	Mortola, 1984
	rat		NS	48	NS	0.30	0.2750	Lin et al., 1983
Other laboratory mammals	cat		NS	4	1.7	0.11880	0.0950	Mortola, 1984
	cat		NS	NS	NS	2.450	0.3220	Lumb, 1963
	cat		NS	6	NS	2.750	0.420	Mazzarelli et al., 1986
	cat		NS	19	NS	2.40	0.48050	Wang and Nims, 1948
	cat		NS	4	NS	2.550	0.68350	Bartlett and Tennet, 1970
	cat		NS	6	NS	3.250	0.77380	Siafakas et al., 1983
	cat		NS	6	NS	3.250	0.7850	Siafakas et al., 1983
	cat		NS	6	547	3.620	0.830	Gautier, 1986
	dog	beagle	M&F	12	364	9.0	3.30	Mauderly et al., 1979
	dog	beagle	M&F	100	395.5	9.10	3.720	Mauderly, 1974
	dog	beagle	M&F	20	1,277.5	11.10	4.060	Mauderly, 1974
	dog	beagle	F	50	395.5	8.40	3.60	Mauderly, 1974
	dog	beagle	F	10	1,277.5	10	3.610	Mauderly, 1974
	dog	beagle	F	36	3,375	10.90	3.810	Mauderly, 1974
	dog	mongrel	F	1	3,650	13.50	6.60	Amoroso et al., 1964
	dog	beagle	M	50	395.5	10	3.650	Mauderly, 1974
	dog	beagle	M	10	1,277.5	12.0	4.510	Mauderly, 1974
	dog	mongrel	M	1	1,460	59.0	11.90	Amoroso et al., 1964
	dog	beagle	NS	12	NS	9.20	1.6620	Stara et al., 1980
	dog	beagle	NS	39	210	9.10	5.280	Pickrell et al. 1971
	dog		NS	3	1	0.29720	0.24180	Mortola, 1984
	dog		NS	1	NS	16.40	4.10	Lumb, 1963
	dog		NS	1	NS	28.60	5.150	Lumb, 1963
	dog		NS	1	NS	19.10	5.450	Lumb, 1963
	dog		NS	1	NS	30.50	6.250	Lumb, 1963

TABLE 4-1 (cont.)

Group	Species	Strain	Sex	No. of Animals	Age (days)	Weight (kg)	Minute Volume (ℓ)	Reference
Other laboratory mammals (cont.)	rabbit	Dutch	M&F	42	NS	2.0510	1.6450	Barrow et al., 1971
	rabbit	New Zealand white	M&F	9	98	3.0	1.240	Mauderly et al., 1979
	rabbit	New Zealand white	NS	5	NS	2.170	0.4490	Maskrey and Nicol, 1980
	rabbit	New Zealand white	NS	5	NS	2.170	0.7440	Maskrey and Nicol, 1980
	rabbit		NS	4	1.7	0.07930	0.05540	Mortola, 1984
	rabbit		NS	31	NS	2.020	0.80	Guyton, 1947
	rabbit		NS	NS	NS	2.070	0.80	Lumb, 1963
	rabbit			58	NS	2.0	0.920	Barrow, 1976
Livestock	camel		NS	NS	NS	550	55.0	Hugh-Jones et al., 1978
	cattle	guernsey, fg	F	1	1,460	460	125.60	Amoroso et al., 1964
	cattle	guernsey, fg	F	1	2,920	410	127.80	Amoroso et al., 1964
	cattle	jersey, heifer	F	1	730	340	59.30	Amoroso et al., 1964
	chicken	leghorn	M&F	6	NS	1.80	0.4050	Gleeson, 1986
	chicken		NS	NS	NS	2.60	0.3230	Lasiewski and Calder, 1971
	donkey		F	1	1,825	120	19.10	Amoroso et al., 1964
	goat	several	F	3	1,095	52.50	12.340	Watkins et al., 1973
	horse	shetland type	M&F	3	NS	167.0	28.60	Mauderly, 1975
	horse	Equus caballus	F	1	9,125	500	31.20	Amoroso et al., 1964
	horse	shetland type	F	1	NS	135.0	23.20	Mauderly, 1975
	horse	shetland type	F	1	NS	161.0	45.20	Mauderly, 1975
	horse	Equus caballus	M	1	NS	510	35.10	Amoroso et al., 1964
	horse	Equus caballus	M	1	2,190	410	40.0	Amoroso et al., 1964
	horse	Equus caballus	M	1	2,920	360	54.10	Amoroso et al., 1964
	horse	Equus caballus	M	1	5,475	600	59.70	Amoroso et al., 1964
	horse	shetland type	M	1	NS	205.0	19.90	Mauderly, 1975
	horse		NS	NS	1,971	481.0	208.0	NAS, 1971
	mule		M	1	4,745	210	19.50	Amoroso et al., 1964
	pig	Sus scrofa	F	1	183	17.0	19.10	Amoroso et al., 1964
	pig		NS	8	1.3	1.180	0.46920	Clement et al., 1986
	pig		NS	3	1	1.16700	0.66590	Mortola, 1984
	pig		NS	15	114	30	7.2570	Clement et al., 1986
	sheep	Ovis aries	F	1	730	52.0	28.0	Amoroso et al., 1964
	sheep		M	6	NS	36.0	5.580	Albelda et al., 1986
	sheep		NS	7	NS	38.0	7.60	Abraham et al., 1981

TABLE 4-1 (cont.)

Group	Species	Strain	Sex	No. of Animals	Age (days)	Weight (kg)	Minute Volume (ℓ)	Reference
Wildlife	deer	red	NS	NS	NS	83.0	9.0	Hugh-Jones et al., 1978
	ferret		M	9	NS	0.71150	0.1570	Vinegar et al., 1985
	fox	Arctic	NS	3	NS	3.60	0.6850	Casey et al., 1979
	fox	Arctic	NS	NS	NS	3.60	0.6850	Withers et al., 1979
	giraffe		NS	NS	NS	400	30.0	Hugh-Jones et al., 1978
	lemming	brownng	NS	NS	NS	0.0640	0.05220	Withers et al., 1979
	lemming	brown	NS	6	NS	0.0640	0.05220	Casey et al., 1979
	lemming	collared	NS	6	NS	0.0470	0.03020	Casey et al., 1979
	lemming	varying	NS	NS	NS	0.0470	0.03010	Withers et al., 1979
	llama		NS	NS	NS	105.0	8.50	Hugh-Jones et al., 1978
	lynx	Canada	NS	1	NS	12.930	3.740	Casey et al., 1979
	lynx		NS	NS	NS	12.930	3.740	Withers et al., 1979
	manatee		NS	NS	NS	250	45.0	Lumb, 1963
	marmot		NS	NS	NS	2.130	0.1740	Lumb, 1963
	muskrat		M&F	10	NS	0.79450	0.3550	MacArthur, 1984
	porpoise		NS	NS	NS	170	9.70	Lumb, 1963
	seal		NS	NS	NS	27.520	3.970	Lumb, 1963
	sloth	Bradypus grise-	NS	NS	NS	3.10	0.4850	Lumb, 1963
	sloth	Cholepus hoffm-	NS	NS	NS	4.50	0.8440	Lumb, 1963
	squirrel	Arctic ground	NS	3	NS	0.680	0.4290	Casey et al., 1979
	squirrel	Arctic ground	NS	NS	NS	1.460	0.4290	Withers et al., 1979
	vole	tundra	NS	6	NS	0.0320	0.02740	Casey et al., 1979
	vole	tundra	NS	NS	NS	0.0320	0.02740	Withers et al., 1979
	weasel	least	NS	4	NS	0.0750	0.05350	Casey et al., 1979
	weasel	least	NS	NS	NS	0.0750	0.05350	Withers et al., 1979
	wolverine		NS	NS	NS	14.0	2.9360	Withers et al., 1979
	wolverine		NS	3	NS	14.10	2.9360	Casey et al., 1979

TABLE 4-1 (cont.)

Group	Species	Strain	Sex	No. of Animals	Age (days)	Weight (kg)	Minute Volume (ℓ)	Reference
Birds	bobwhite		M&F	5	NS	0.1990	0.1350	Boggs and Kilgore, 1983
	burrowing owl		M&F	5	NS	0.1660	0.1290	Boggs and Kilgore, 1983
	duck	white peking	NS	5	NS	2.50	0.9310	Jones, 1985
	duck		NS	NS	NS	1.60	0.7650	Lasiewski and Calder, 1971
	goose		NS	NS	NS	6.80	1.50	Lasiewski and Calder, 1971
	ostrich		NS	NS	NS	88.0	8.10	Lasiewski and Calder, 1971
	pigeon		NS	NS	NS	0.3820	0.12740	Lasiewski and Calder, 1971
	quail	painted	NS	NS	NS	0.04340	0.02380	Lasiewski and Calder, 1971
Other	lizard	monitor		4	NS	0.030	0.00140	Bickler and Anderson, 1986
	turtle	diamond-back	NS	NS	NS	0.6850	0.0510	Lumb, 1963

NS = Not specified

from studies on inhalation exposure of free-living animals, the use of an activity correction factor may be appropriate.

The U.S. EPA (1980) has used the following equations to calculate inhalation rates (I) in units of m^3/day for mice and rats:

$$I\ (\text{mice}) = 0.0345[W/0.025]^{2/3} \quad (4\text{-}1)$$

$$I\ (\text{rats}) = 0.105[W/0.133]^{2/3} \quad (4\text{-}2)$$

where W is body weight in kg. The equation for rats is based on observations summarized by Altman and Dittmer (1972) and originally published by Guyton (1947), in which rats with a mean body weight of 0.1128 had a mean minute volume of 72.9 mℓ (0.105 m^3/day). The equation for mice is similarly derived but the mouse weight is erroneously indicated to be 0.025 kg. The actual value reported by Guyton (1947) is 0.0198 kg and is reported in Altman and Dittmer (1972) as 0.02 kg. The minute volume reported by Guyton (1947) is 24.54 mℓ (0.0353 m^3/day). Taking body weight ratios to the 2/3 power assumes that breathing rates are proportional to body surface area.

Reported minute volumes for a wide range of animals at rest are summarized in Table 4-1 and illustrated in Figures 4-1 (linear plot) and 4-2 (log-log plot). While Figure 4-2 shows a relatively clear relationship between log body weight and log minute volume, certain points are atypical and are not considered in the derivation of recommended values. Three of these points come from the study by Amoroso et al. (1964): sheep, miniature pigs, and Guernsey cattle. Most of the reported values given by Amoroso et al. (1964) are high compared with other studies. In this study, tidal volume was measured by a flow transducer attached to a mask that was sealed with jelly and made air-tight with an inflatable cuff. In addition, none of the animals were trained or subjected to such measurements prior to the published recordings. These factors may have contributed to the atypically high recorded minute volumes.

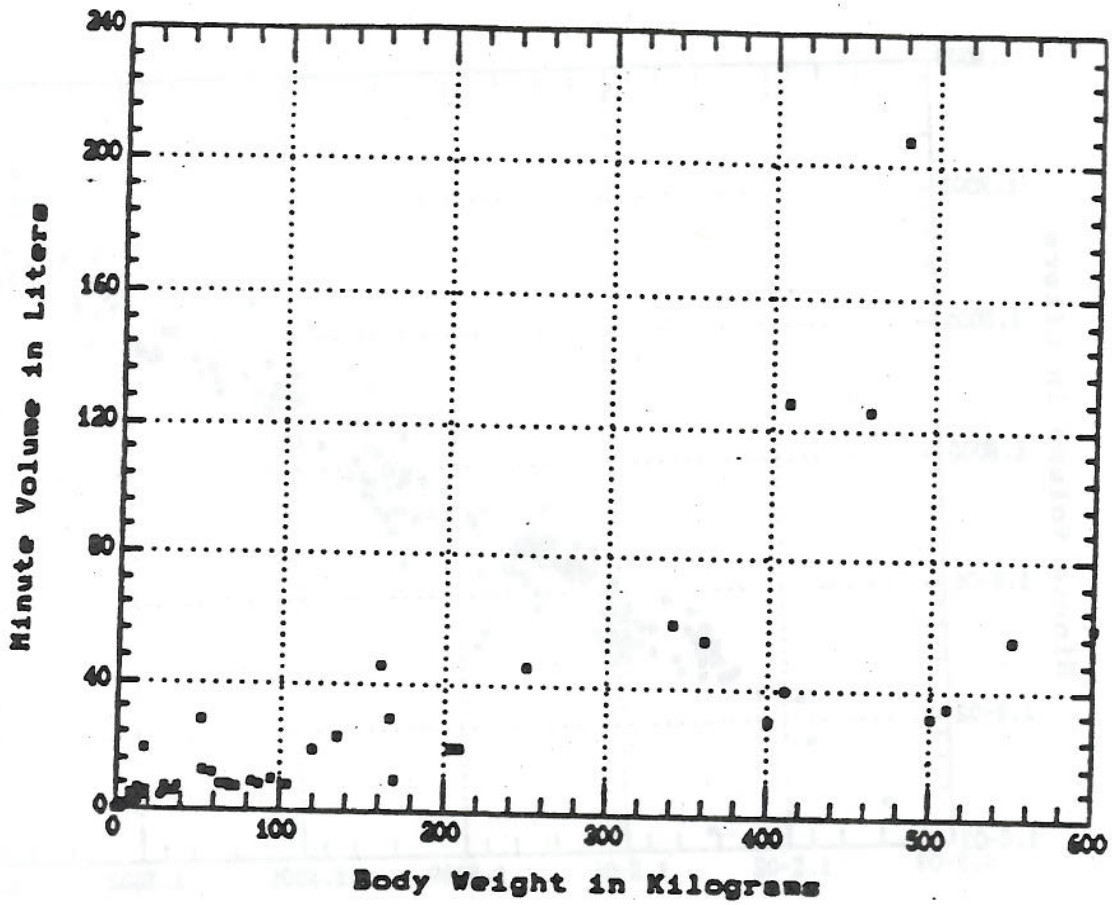


FIGURE 4-1

Linear Plot of the Relationship of
Minute Volume (ℓ) to Body Weight (kg)

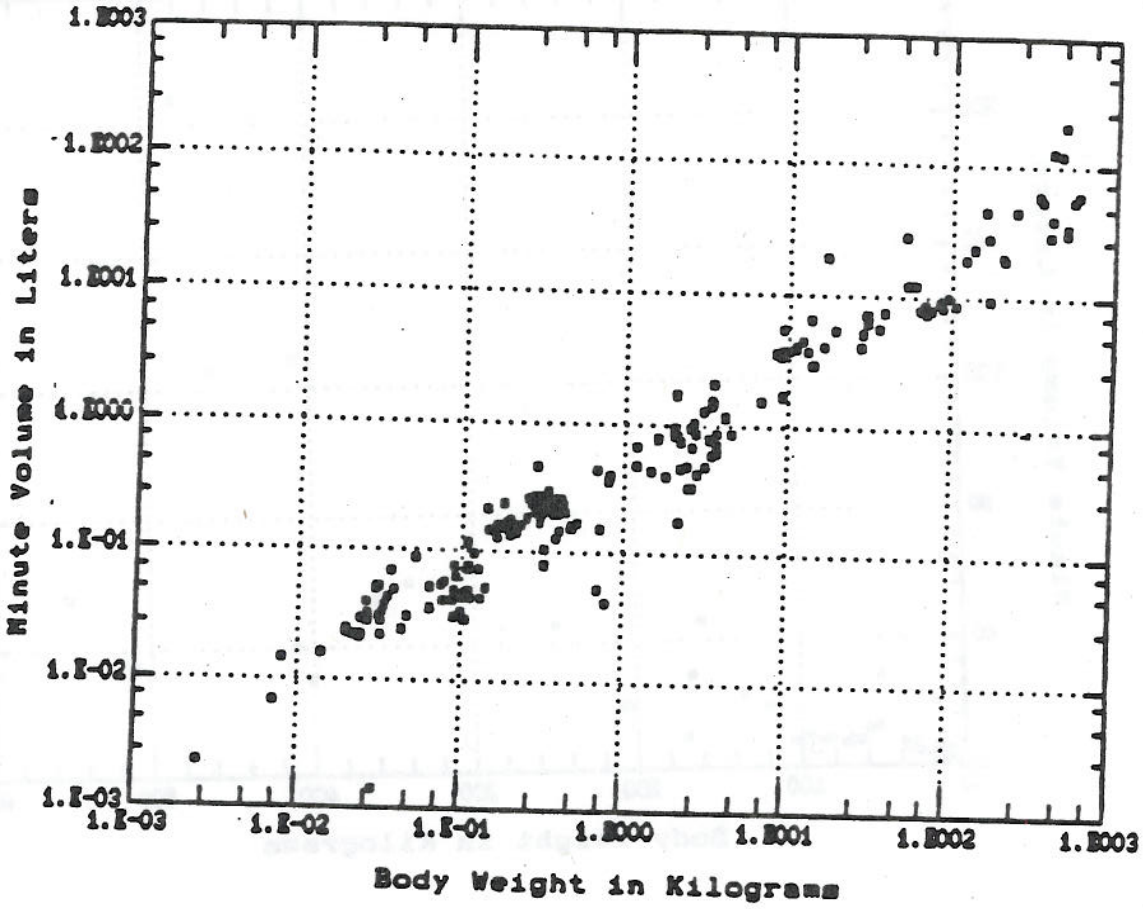


FIGURE 4-2

Log-Log Plot of the Relationship of
Minute Volume (ℓ) to Body Weight (kg)

In the study by Lai et al. (1978), one group of rats, subjected to tracheal cannulation without anesthesia, had an atypically high mean minute volume compared with three other groups in the study and compared with minute volumes of rats reported in other studies. This group of rats is not used in the recommendation of reference values.

Also excluded are reported minute volumes for the Monitor lizard (Lumb, 1963), the Diamond-back turtle (Bickler and Anderson, 1986) and the value reported for horses by NAS (1971).

The exclusion of the above points is not intended to suggest that the studies were flawed or that the values are erroneous or necessarily outliers in the statistical sense. Given the experimental difficulties in recording minute volumes, the substantial degree of scatter is to be expected. Nonetheless, the excluded points are clearly at variance with the majority of the data on the same species or other species of similar body weights. The exclusion of these points does not have a substantial effect on the statistical analyses below or on the recommendations of reference inhalation rates for risk assessment.

The work of Guyton (1947) is the best study of comparative respiratory volumes in laboratory animals and is commonly cited in the recent literature as the basis for assumed respiratory volumes. Guyton (1947) used five different methods, only one of which involved anesthesia, to measure respiratory rates of animals at rest. As noted by Guyton (1947) and confirmed by the larger data set in Figure 4-2, there is a strong positive correlation between body weight and minute volume for species, covering a substantial weight range (0.0066-600 kg). As noted by Guyton (1947) and Adolph (1949), however, this relationship does not appear to be based on the surface area proportionality. Guyton (1947) proposed a proportionality of body weight to

the 3/4 power. An analysis of the data summarized in Table 4-1, excluding only those points discussed previously, bears out this relationship remarkably well:

$$\ln MV = -0.88 + 0.7579 \ln (W) \quad (4\text{-}3)$$

or

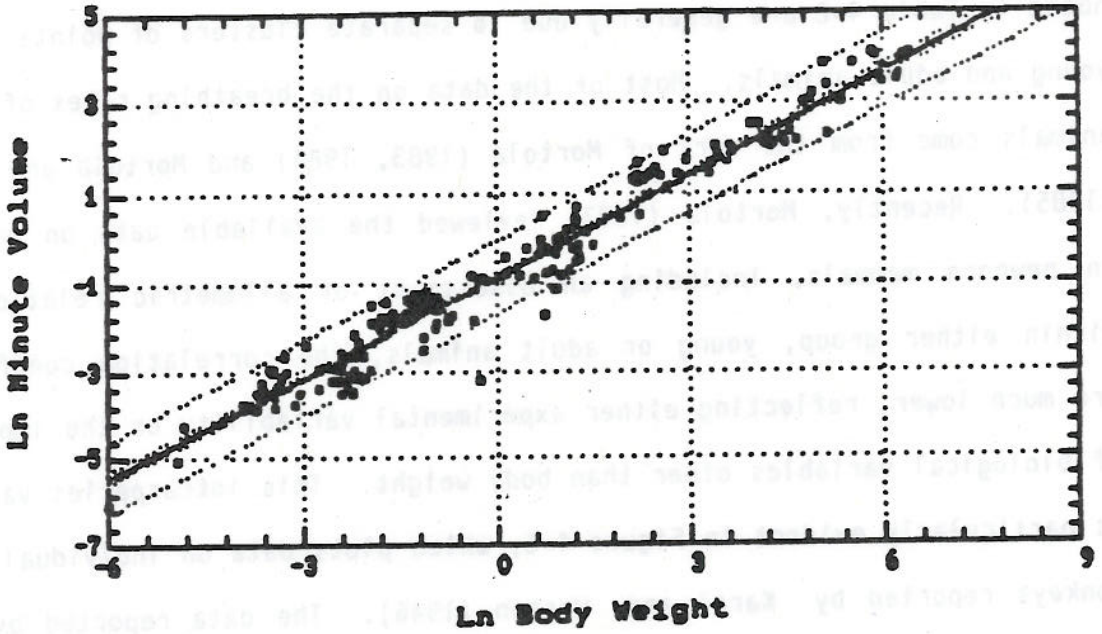
$$MV = 0.46\ (W)^{0.7579} \quad (4\text{-}4)$$

This relationship, along with summary statistics, is illustrated in Figure 4-3. Equations 4-3 and 4-4 are recommended for calculating minute volumes (MV in ℓ/minute) for body weight (W in kg) for animals at rest if more specific relationships, detailed below, are not available. Equation 4-4 can be converted to a daily inhalation volume (I) by multiplying the right side of the equation by 1.44 (60 minutes/hourx24 hours/day divided by 1000 ℓ/m³) to yield:

$$I = 0.66\ (W)^{0.7579} \quad (4\text{-}5)$$

This equation is based on the breathing pattern of animals reportedly at rest. When applied to risk assessments, consideration should be given to upper or lower bound estimates of breathing rates, based on the summary statistics provided in Figure 4-3, if unusually high or low levels of activity are reported in the study under review.

No species, with the possible exceptions of the Monitor lizard and Diamond-back turtle, are clear outliers to the above relationships. Even for the apparent outliers, it is unclear if the differences in minute volumes from those of species of similar body weights are due to true species differences or experimental variability or error. Nonetheless, if species-specific information is available on the relationship of body weight



B0: -0.88283 SE: 0.0281 T: -31.417
B1: 0.75794 SE: 0.010108 T: 75.021
CORR: 0.98084 MSE: 0.17593 DF: 222

FIGURE 4-3

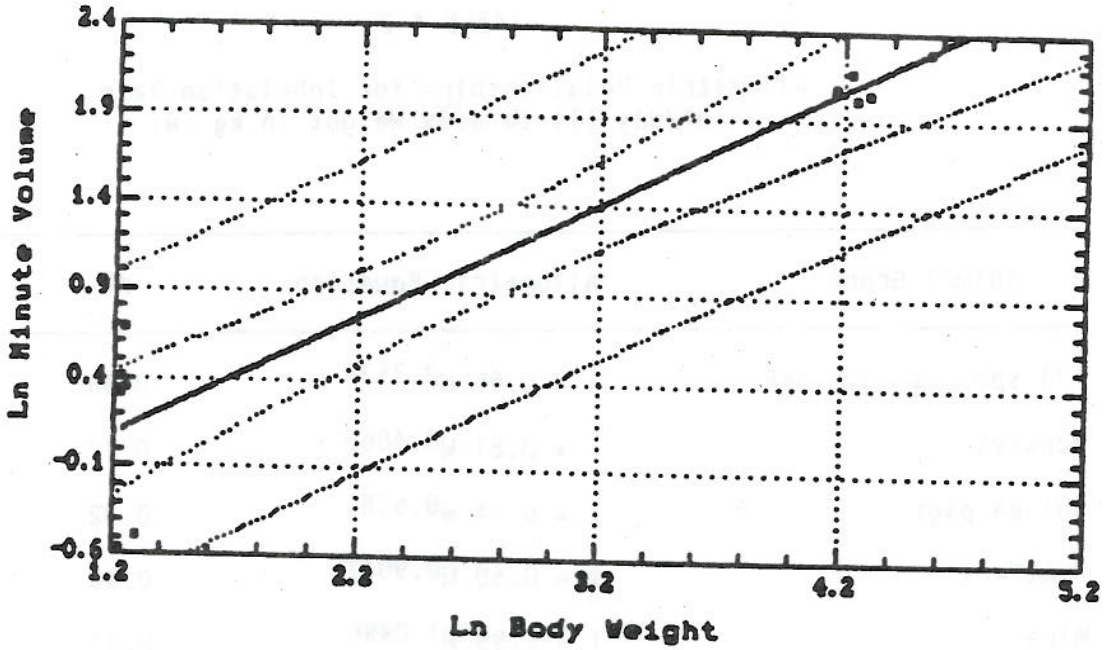
Allometric Relationship of Minute Volume (ℓ) to Body Weight (kg) for All Species

to inhalation rate, this information should be used in deriving species-specific recommended values. As summarized in Table 4-2 and Figures 4-4 through 4-14, species-specific allometric equations can be proposed for most species of concern in risk assessment. The high correlation coefficients noted in Table 4-2 are generally due to separate clusters of points for very young and adult animals. Most of the data on the breathing rates of newborn animals come from the work of Mortola (1983, 1984) and Mortola and Noworaj (1985). Recently, Mortola (1987) reviewed the available data on breathing in newborn mammals, including an assessment of allometric relationships. Within either group, young or adult animals, the correlation coefficients are much lower, reflecting either experimental variability or the importance of biological variables other than body weight. This intraspecies variation is particularly evident in Figure 4-6, which plots data on individual Rhesus monkeys reported by Karel and Weston (1946). The data reported by Cross (1949) appear to be atypically low, both for human infants when compared with the more recent data of Fisher et al. (1982) as for humans and monkeys combined (see Figure 4-7). The allometric relationship for guinea pigs has a very low correlation coefficient. The reasons for the poor correlation in this species are not apparent.

TABLE 4-2

Allometric Relationships for Inhalation Rate in m^3/day (I) to Body Weight in kg (W)

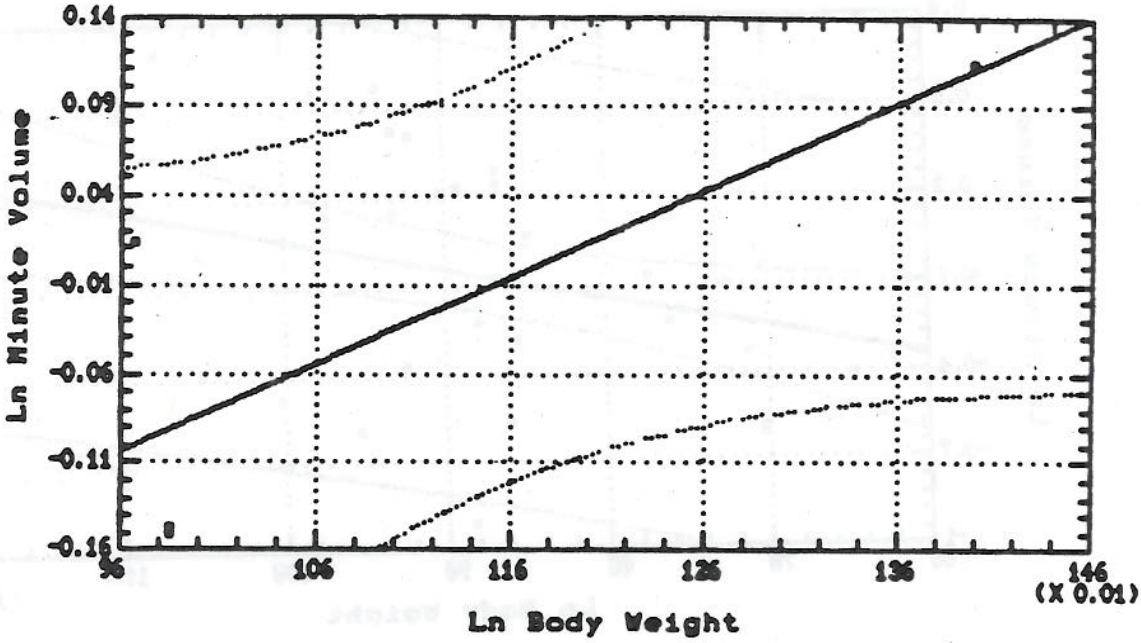
Animal Group	Allometric Equation	r^2	Figure
All species combined	$I = 0.66\ W^{0.7579}$	0.96	4-3
Monkeys	$I = 0.81\ W^{0.4862}$	0.72	4-5
Guinea pigs	$I = 0.44\ W^{0.5156}$	0.32	4-8
Hamsters	$I = 0.50\ W^{0.9017}$	0.86	4-9
Mice	$I = 1.99\ W^{1.0496}$	0.87	4-10
Rats	$I = 0.80\ W^{0.8206}$	0.77	4-11
Cats	$I = 0.32\ W^{0.5945}$	0.81	4-12
Dogs	$I = 0.67\ W^{0.7091}$	0.89	4-13
Rabbits	$I = 0.46\ W^{0.8307}$	0.88	4-14



B0: -0.70048 SE: 0.22409 T: -3.1258
B1: 0.65865 SE: 0.070967 T: 9.281
CORR: 0.94656 MSE: 0.14002 DF: 10

FIGURE 4-4

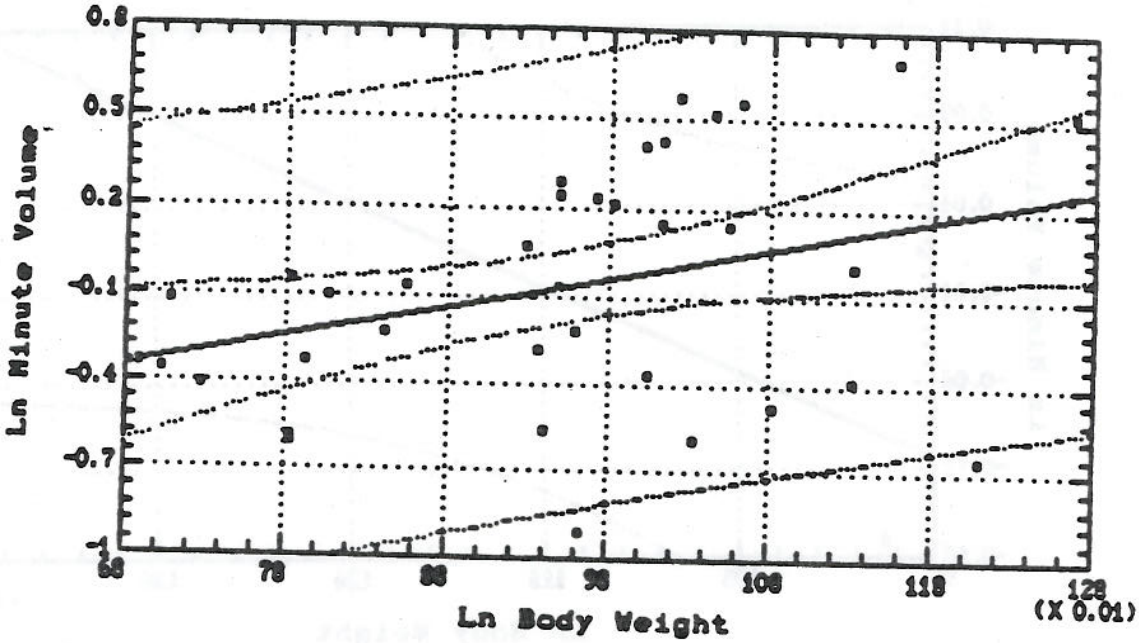
Allometric Relationship of
Minute Volume (ℓ) to Body Weight (kg) for Humans



B0: -0.56924 SE: 0.20599 T: -2.7634
B1: 0.48616 SE: 0.17675 T: 2.7506
CORR: 0.8462 MSE: 6.5944E-3 DF: 3

FIGURE 4-5

Allometric Relationship of
Minute Volume (ℓ) to Body Weight (kg) for Monkeys
(All data in Table 4-1)

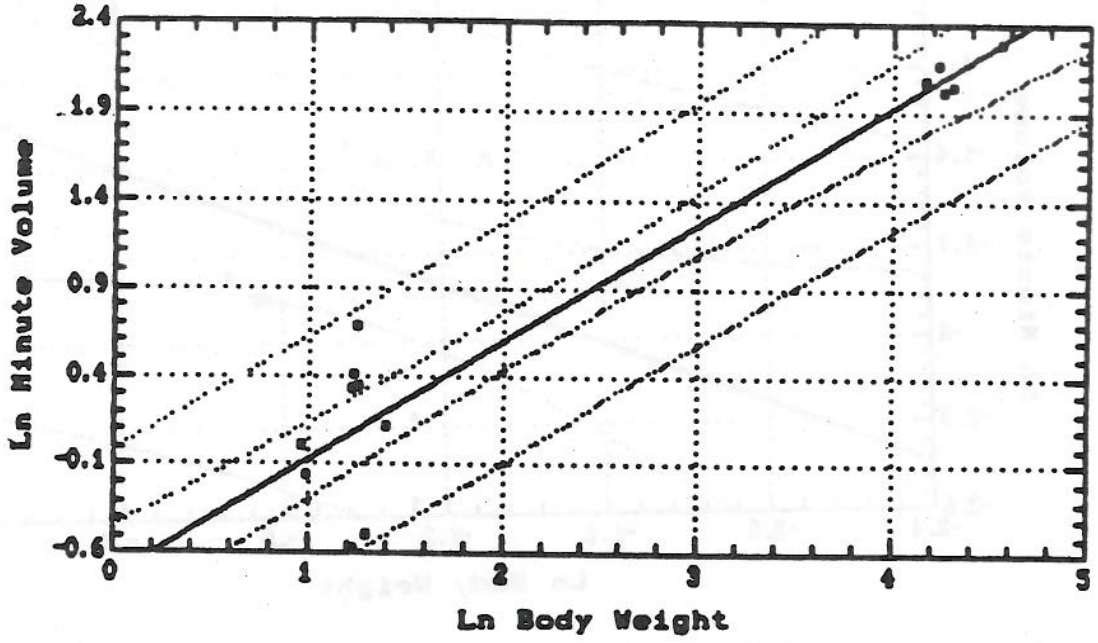


B0: -1.0573 SE: 0.39644 T: -2.6669
B1: 1.0381 SE: 0.40928 T: 2.5365
CORR: 0.38487 MSE: 0.14022 DF: 37

FIGURE 4-6

Allometric Relationship of Minute Volume (ℓ) to Body Weight (kg) for Individual Rhesus Monkeys

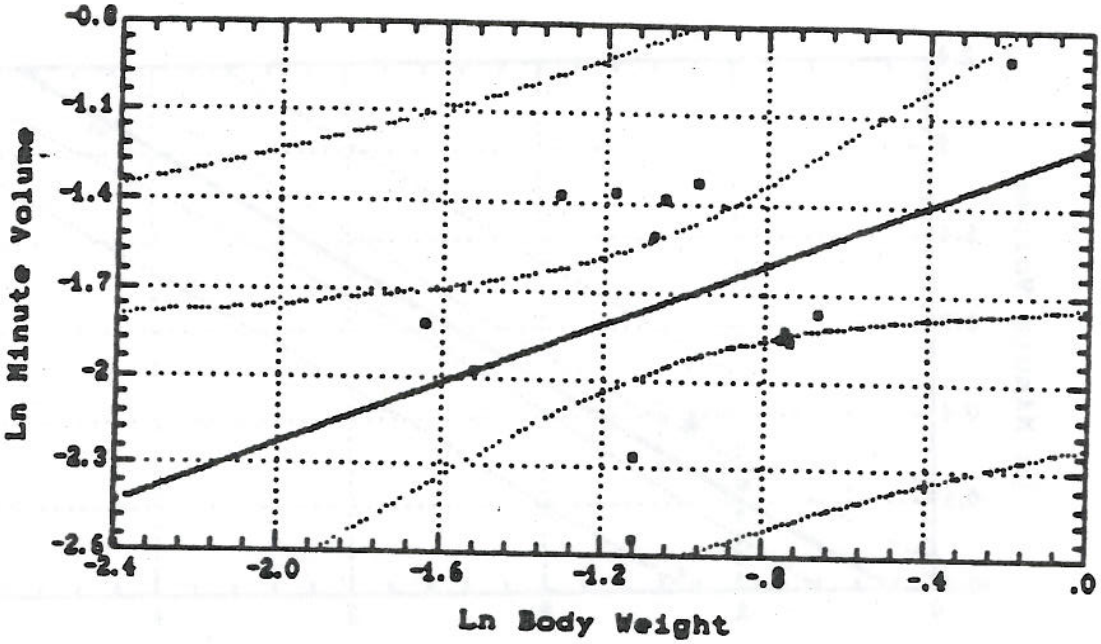
(Data from Karel and Weston, 1946, not summarized in Table 4-1)



B0: -0.74125 SE: 0.13836 T: -5.3575
B1: 0.66789 SE: 0.050731 T: 13.165
CORR: 0.95935 MSE: 0.095919 DF: 15

FIGURE 4-7

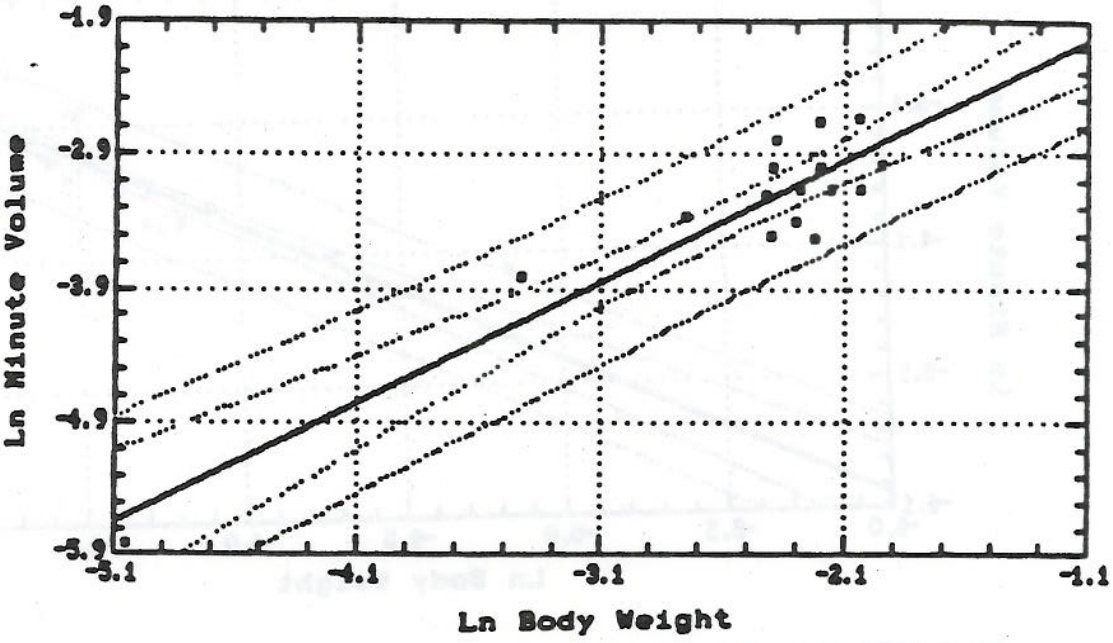
Allometric Relationship of Minute Volume (ℓ) to Body Weight (kg) for Humans and Monkeys Combined



B0: -1.1909 SE: 0.25402 T: -4.6884
B1: 0.51559 SE: 0.21094 T: 2.4442
CORR: 0.56113 MSE: 0.15895 DF: 13

FIGURE 4-8

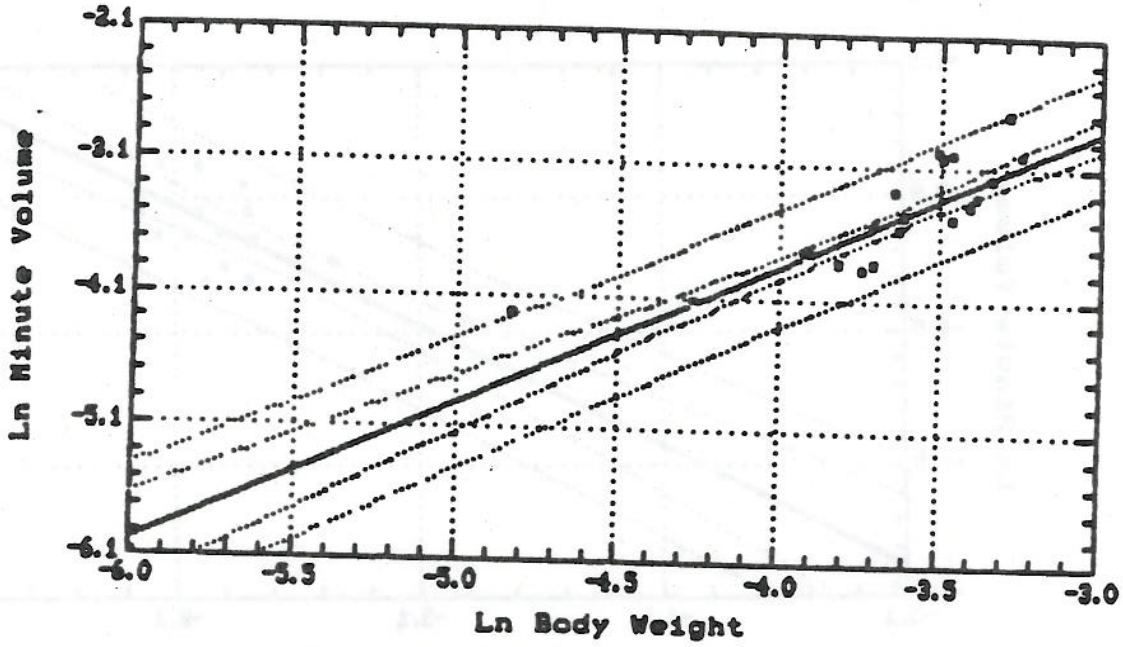
Allometric Relationship of Minute Volume (ℓ) to Body Weight (kg) for Guinea Pigs



B0: -1.054 SE: 0.24428 T: -4.3147
B1: 0.90168 SE: 0.094009 T: 9.5914
CORR: 0.92726 MSE: 0.076956 DF: 15

FIGURE 4-9

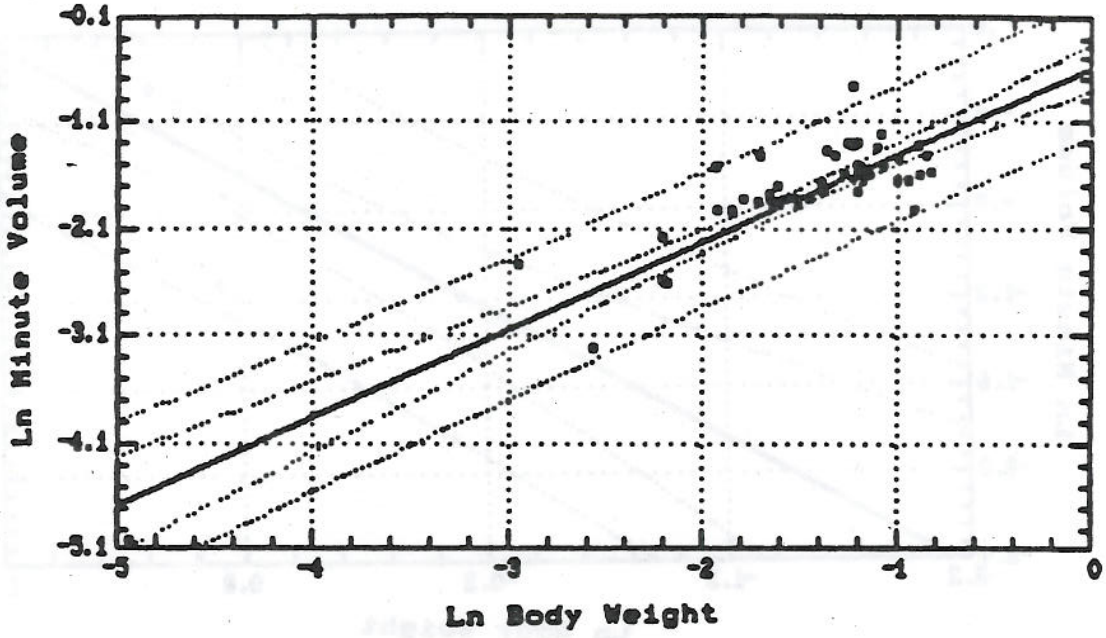
Allometric Relationship of Minute Volume (ℓ) to Body Weight (kg) for Hamsters



B0: 0.32599 SE: 0.2764 T: 1.1794
B1: 1.0496 SE: 0.07377 T: 14.228
CORR: 0.93224 MSE: 0.045477 DF: 30

FIGURE 4-10

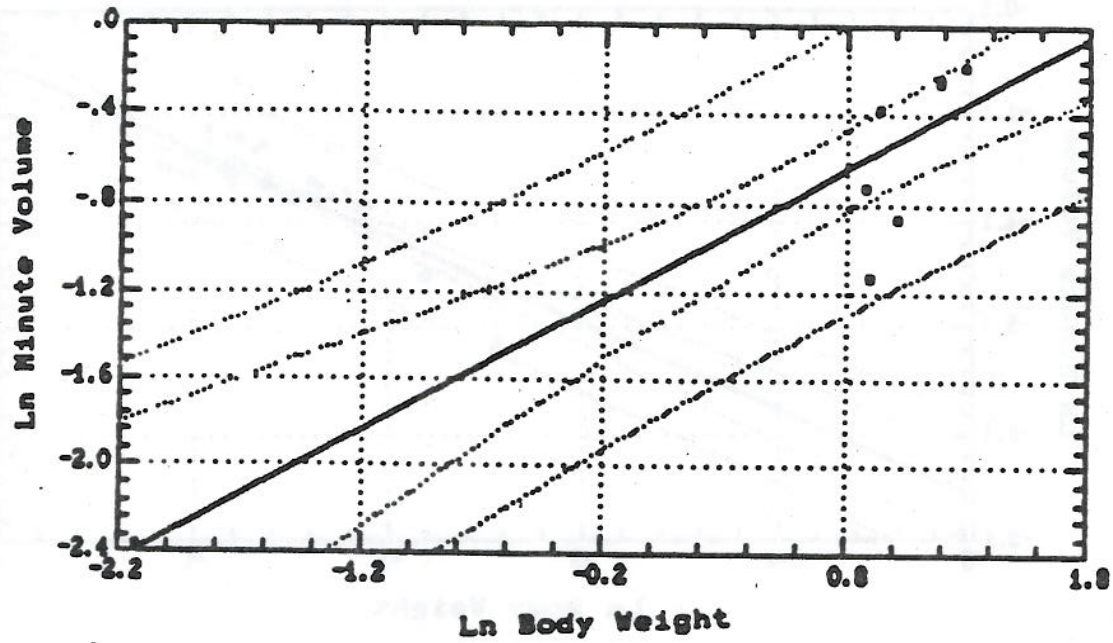
Allometric Relationship of Minute Volume (ℓ)
to Body Weight (kg) for Mice



B0: -0.57838 SE: 0.10607 T: -5.4531
B1: 0.82061 SE: 0.06357 T: 12.909
CORR: 0.87704 MSE: 0.096214 DF: 30

FIGURE 4-11

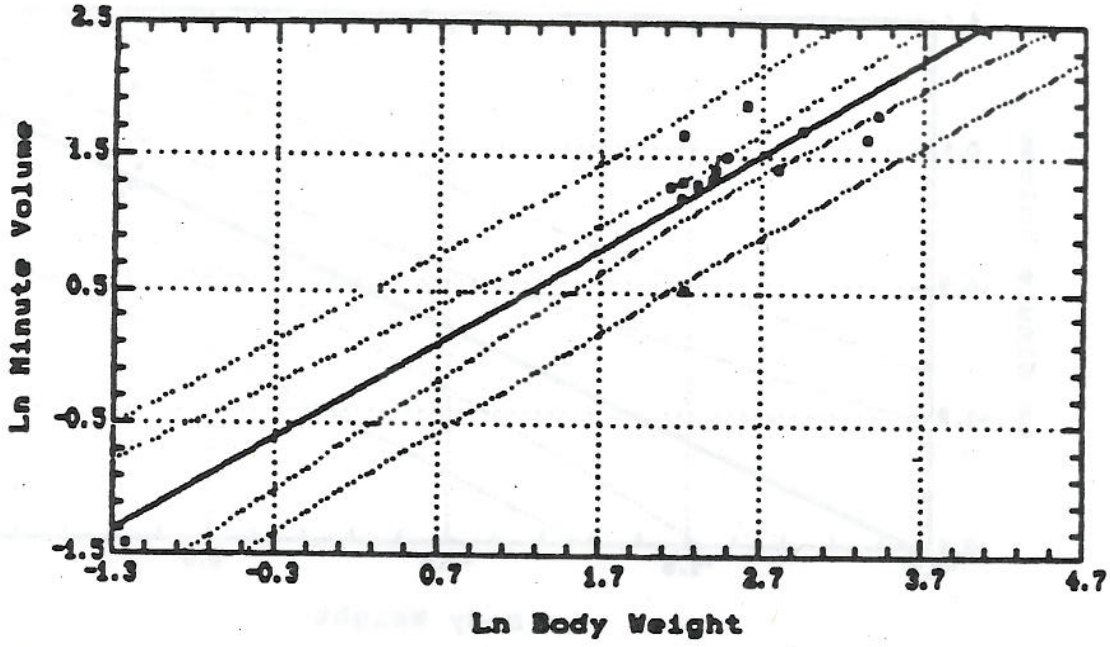
Allometric Relationship of Minute Volume (ℓ)
to Body Weight (kg) for Rats



B0: -1.1287 SE: 0.10625 T: -10.623
B1: 0.59451 SE: 0.091748 T: 6.4798
CORR: 0.89869 MSE: 0.07798 DF: 10

FIGURE 4-12

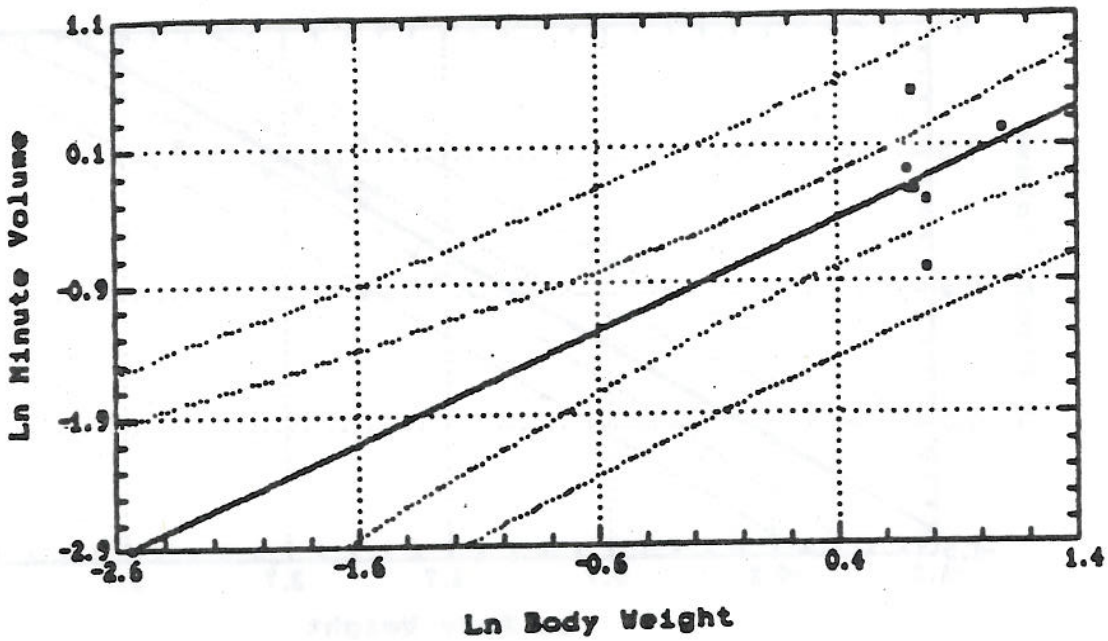
Allometric Relationship of Minute Volume (ℓ)
to Body Weight (kg) for Cats



B0: -0.39103 SE: 0.17066 T: -2.2913
B1: 0.7091 SE: 0.065154 T: 10.883
CORR: 0.94212 MSE: 0.078804 DF: 15

FIGURE 4-13

Allometric Relationship of Minute Volume (ℓ) to Body Weight (kg) for Dogs



B0: -0.7827 SE: 0.14872 T: -5.2627
B1: 0.83065 SE: 0.1277 T: 6.3048
CORR: 0.93585 MSE: 0.15914 DF: 6

FIGURE 4-14

Allometric Relationship of Minute Volume (ℓ)
to Body Weight (kg) for Rabbits

5. WATER CONSUMPTION

The U.S. EPA (1980) has used a reference value of 2 ℓ/day for water consumption of a 70 kg man. The Office of Drinking Water uses this value and a reference drinking water rate of 1 ℓ/day for a 10 kg child. The Agency has not adopted recommended values for experimental animals.

The rate of water consumption can be affected by many factors including ambient temperature, level of activity, diet, and abnormal physiological or pathological conditions. Chew (1965) extensively reviewed the literature on water balance in mammals, and a similar review was provided by Bartholomew and Cade (1963) on land birds. More recent comprehensive reviews were not found during the preparation of this report. Classic papers on water metabolism include those by Adolph (1947) and Bailey (1923). Only a few of the many examples of factors affecting water intake are given below.

The effects of reproductive status on water intake can be substantial. For instance, pregnant or lactating cows consume about 4 times as much water as nonlactating cows (Mount and Ingram, 1971), and chickens in the egg-producing stage consume about twice the amount of water of nonproducing chickens (Howard, 1975).

Also, several examples have been reported on the effect of diet on water consumption. For guinea pigs, the amount of "greens" (usually kale or lettuce) in the diet is inversely related to water requirements. Guinea pigs receiving a green food supplement require only 50-100 mℓ water/day, but without the supplement, guinea pigs require 25-100 mℓ/day (Ediger, 1976). Dogs consuming canned food, with an average moisture content of 75%, may not require any additional water consumption (Corbin, 1976). A significant increase in the salt content of the diet can substantially increase

water consumption, as demonstrated in mink when given 1 and 2% salt-enhanced diets. No change in water consumption was seen in mink fed a 0.5% salt-enhanced diet (Erikson et al., 1984). Variations of dietary salt within normal limits does not appear to affect the water intake of humans (Luft et al., 1983).

Seasonal differences or changes in ambient temperature also can affect water intake for lions (Green et al., 1984) and for turkeys (Parker et al., 1972). Remarkable decreases in water and food consumption occur in hibernating animals before hibernation for marmots (Zatzman et al., 1984). In some cases, seasonal differences are not substantial, as with the early food and water intake of neonatal calves (Kertz et al., 1984).

In a study on chickens with hereditary diabetes insipidus, Dunson et al. (1972) reviewed information on several strains of laboratory animals, none of which are commonly used in toxicity bioassays, with hereditary polydipsia.

These and other confounding factors may be related to the generally poor intraspecies correlations of water intake and body weight discussed below. Despite the number of variables that can affect water consumption, interspecies correlations covering a wide range of body weights are generally high. Using data on several mammalian species, Adolph (1943) proposed the following relationship:

$$L = 0.01\ W^{0.88} \qquad (5\text{-}1)$$

where L is water consumption in mℓ/hour and W is body weight in grams. A similar relationship ($W^{0.9}$) had been noted somewhat earlier by Richter (1938).

Table 5-1 summarizes data on water consumption for several species of animals. [Many of the references cited in this table are reviews or standard texts (Arrington, 1978; Bruce, 1950; Chew, 1975; Cizek, 1961;

TABLE 5-1

Water Consumption Data on Various Animal Groups

Group	Species	Strain	Sex	No. of Animals	Age (days)	Weight (g/day)	Water	Reference
Primates	baboon	P. ursinus	NS			21.1	1.31	Chew, 1965
	human		M			70	2.184	Adolph and Dill, 1938
	human		M			65	2.275	Altman and Dittmer, 1968
	human		M	24	6935+	78.6	3.239	Luft et al., 1983
	monkey	rhesus	F			8	0.45	Templeton, 1968
	monkey	rhesus	F			9	0.45	Arrington, 1972
	monkey	rhesus	M			11	0.45	Arrington, 1972
	monkey	rhesus	M			11	0.45	Templeton, 1968
	monkey	NS	NS			5.45	0.39	Chew, 1965
Laboratory rodents	gerbil	Mongolian	M&F	20	215	0.06125	0.0038	Harriman, 1969a
	gerbil	Mongolian	M&F	16-20	adult	0.06125	0.00565	McManus, 1972
	gerbil	Mongolian	F			0.075	0.004	Templeton, 1968
	gerbil		F			0.075	0.004	Arrington, 1972
	gerbil	Mongolian	M			0.085	0.004	Templeton, 1968
	gerbil	Mongolian	M	11	70-80	0.0705	0.0055	Laughlin et al., 1975
	gerbil		M			0.085	0.004	Arrington, 1972
	guinea pig		F			1.025	0.09	Arrington, 1972
	guinea pig	albino short-hair	M	5	10	0.2	0.04	Hirsch, 1973
	guinea pig	albino short-hair	M	5	20	0.27	0.052	Hirsch, 1973
	guinea pig	albino short-hair	M	5	30	0.11	0.08	Hirsch, 1973
	guinea pig	albino short-hair	M	5	60	0.52	0.11	Hirsch, 1973
	guinea pig	albino short-hair	M	5	40	0.415	0.115	Hirsch, 1973
	guinea pig	albino short-hair	M	5	50	0.48	0.12	Hirsch, 1973
	guinea pig	albino short-hair	M	5	70	0.58	0.151	Hirsch, 1973
	guinea pig		M			1.2	0.09	Arrington, 1972

TABLE 5-1 (cont.)

Group	Species	Strain	Sex	No. of Animals	Age (days)	Weight (g/day)	Water	Reference
Laboratory rodents	guinea pig		NS			0.1	0.08	Latt, 1976
	guinea pig		NS		adult	0.8	0.084	Bruce, 1950
	guinea pig		NS		adult	0.8	0.084	Lane-Peter et al., 1967
	guinea pig		NS			0.3	0.12	Latt, 1976
	guinea pig		NS			0.4	0.145	Latt, 1976
	guinea pig		NS			0.5	0.16	Latt, 1976
	guinea pig		NS			0.7	0.18	Latt, 1976
	guinea pig		F			1	0.09	Templeton, 1968
	guinea pig		M			1.2	0.09	Templeton, 1968
	hamster	Syrian	F			0.0545	0.009	Templeton, 1968
	hamster	Syrian	F			0.1175	0.01	Arrington, 1972
	hamster	Syrian	M			0.05125	0.009	Templeton, 1968
	hamster	golden	NS		adult	0.09	0.008	Lane-Peter et al., 1967
	hamster		NS			0.025	0.005	Latt, 1976
	hamster		NS		adult	0.09	0.008	Bruce, 1950
	hamster		NS			0.05	0.01	Latt, 1976
	hamster		NS			0.1	0.02	Latt, 1976
	hamster		NS			0.15	0.025	Latt, 1976
	mouse	A/J	F	15	(100-110)	0.0209	0.0047	Kutscher, 1974
	mouse	BALB/c	F	15	(100-110)	0.0201	0.0056	Kutscher, 1974
	mouse	CB A	F	15	(100-110)	0.0259	0.0065	Kutscher, 1974
	mouse	Crl,CD-1,CR,BR	F	40	182	0.03075	0.0063	Chvedoff et al., 1980
	mouse	Crl,CD-1,CR,BR	F	40	364	0.03475	0.0076	Chvedoff et al., 1980
	mouse	Crl,CD-1,ICR,BR	F	40	546	0.03375	0.00645	Chvedoff et al., 1980
	mouse	C3H	F	15	(100-110)	0.0228	0.0062	Kutscher, 1974
	mouse	C57Bl/6Jms	F	63		0.0252	0.00359	Suzuki et al., 1975
	mouse	C57	F	15	(100-110)	0.0223	0.0062	Kutscher, 1974
	mouse	DBA	F	15	(100-110)	0.0247	0.0079	Kutscher, 1974
	mouse	STR/1N	F	13	152	0.0284	0.0068	Silverstein, 1960

TABLE 5-1 (cont.)

Group	Species	Strain	Sex	No. of Animals	Age (days)	Weight (g/day)	Water	Reference
Laboratory rodents (cont.)	mouse	SWR	F	15	(100-110)	0.0217	0.011	Kutscher, 1974
	mouse	white	F	8	(105-120)	0.0282	0.0096	Chew and Hinegardner, 1957
	mouse	white	F	8	396	0.0335	0.0106	Chew and Hinegardner, 1957
	mouse	white	F	8	70	0.0248	0.0107	Chew and Hinegardner, 1957
	mouse		F			0.0265	0.0055	Arrington, 1972
	mouse	A/HeN	M	12	152	0.0297	0.0048	Silverstein, 1960
	mouse	A/J	M	15	(100-110)	0.0252	0.0049	Kutscher, 1974
	mouse	A/LN	M	7	152	0.0241	0.0057	Silverstein, 1960
	mouse	BALB/cAnN	M	8	152	0.0256	0.0043	Silverstein, 1960
	mouse	BALB/c	M	15	(100-110)	0.027	0.0048	Kutscher, 1974
	mouse	CBA	M	15	(100-110)	0.031	0.0071	Kutscher, 1974
	mouse	Charles River	M	7	adult	0.0453	0.0043	DeLacey et al., 1975
	mouse	Charles River	M	8	adult	0.0424	0.00479	DeLacey et al., 1975
	mouse	Crl,CD-1,CR,BR	M	40	182	0.0405	0.0065	Chvedoff et al., 1980
	mouse	Crl,CD-1,CR,BR	M	40	546	0.04475	0.00715	Chvedoff et al., 1980
	mouse	Crl,CD-1,CR,BR	M	40	364	0.0455	0.00835	Chvedoff et al., 1980
	mouse	C3H	M	15	(100-110)	0.0264	0.0068	Kutscher, 1974
	mouse	C57Bl/6Jms	M	60		0.0287	0.00391	Suzuki et al., 1975
	mouse	C57L/HeN	M	13	152	0.0264	0.0046	Silverstein, 1960
	mouse	C57	M	15	(100-110)	0.0275	0.0066	Kutscher, 1974
	mouse	DBA/2JN	M	9	152	0.0265	0.0054	Silverstein, 1960
	mouse	DBA	M	15	(100-110)	0.0309	0.0078	Kutscher, 1974
	mouse	STR/N	M	12	152	0.0291	0.01	Silverstein, 1960
	mouse	STR/1N	M	8	152	0.0337	0.01	Silverstein, 1960
	mouse	SWR	M	15	(100-110)	0.0286	0.0094	Kutscher, 1974
	mouse	white	M	8	396	0.0369	0.0106	Chew and Hinegardner, 1957
	mouse	white	M	8	(105-120)	0.0324	0.0109	Chew and Hinegardner, 1957
	mouse	white	M	8	70	0.0297	0.0121	Chew and Hinegardner, 1957

TABLE 5-1 (con

Group	Species	Strain	Sex	No. of Animals	Age (days)	Weight (g/day)	Water	Reference
Laboratory rodents (cont.)	mouse		M			0.03	0.0055	Arrington, 1972
	mouse	albino	NS			0.02875	0.00735	Chew, 1965
	mouse	deer	NS		adult	0.02	0.005	Bruce, 1950
	mouse	deer	NS		adult	0.02	0.005	Lane-Peter et al., 1967
	mouse	deer	NS			0.0189	0.0235	Chew, 1965
	mouse	meadow	NS			0.0315	0.066	Chew, 1965
	mouse	pine	NS			0.0182	0.0018	Chew, 1965
	mouse	white-foot	NS			0.02425	0.0355	Chew, 1965
	mouse	white	NS			0.029	0.00715	Chew, 1965
	mouse		NS		weanling	0.008	0.0025	Bruce, 1950
	mouse		NS			0.01	0.003	Latt, 1976
	mouse		NS			0.025	0.005	Latt, 1976
	mouse		NS		adult	0.025	0.006	Bruce, 1950
	mouse		NS		adult	0.025	0.006	Lane-Peter et al., 1967
	mouse		NS			0.05	0.006	Latt, 1976
	mouse		NS			0.075	0.008	Latt, 1976
	mouse	white			adult	0.0275	0.0065	Bruce, 1950
	rat	kangaroo	M&F	4		0.105	0.0058	Bailey, 1923
	rat		F			0.29	0.0275	Arrington, 1972
	rat		F	1	adult	0.26	0.028	Bruce, 1950
	rat		F	1	adult	0.36	0.03	Bruce, 1950
	rat		F	1	adult	0.26	0.038	Bruce, 1950
	rat		F	1	adult	0.275	0.085	Bruce, 1950
	rat		F	1	adult	0.36	0.085	Bruce, 1950
	rat	albino	M	14	(80-105)	0.2891	0.0354	Moyer, 1966
	rat	Sprague-Dawley	M	10	24-52	0.05	0.0136	Delorme and Wojcik, 1982
	rat	Sprague-Dawley	M	10	24-52	0.05	0.0136	Delorme and Wojcik, 1982
	rat	Sprague-Dawley	M	10	24-52	0.05	0.019	Delorme and Wojcik, 1982
	rat	Sprague-Dawley	M	10	24-52	0.05	0.0242	Delorme and Wojcik, 1982
	rat	Sprague-Dawley	M	10	24-52	0.05	0.0242	Delorme and Wojcik, 1982

TABLE 5-1 (cont.)

Group	Species	Strain	Sex	No. of Animals	Age (days)	Weight (g/day)	Water	Reference
Laboratory rodents (cont.)	rat	Sprague-Dawley	M	10	24-52	0.05	0.0289	Delorme and Wojcik, 1982
	rat	Sprague-Dawley	M	10	24-52	0.05	0.0289	Delorme and Wojcik, 1982
	rat	Sprague-Dawley	M	8	+12	0.442	0.039	Grunberg et al., 1984
	rat	Sprague-Dawley	M	8	180	0.38	0.04	Grunberg et al., 1984
	rat	Sprague-Dawley	M	8	+6	0.422	0.041	Grunberg et al., 1984
	rat		M			0.375	0.0275	Arrington, 1972
	rat	albino	NS	adult		0.3	0.024	Lane-Peter et al., 1967
	rat	cotton	NS	young adult		0.13	0.023	Bruce, 1950
	rat	cotton	NS	young adult		0.13	0.023	Lane-Peter et al., 1967
	rat	D. morroensis	NS			0.068	0.0148	Chew, 1965
	rat	D. panaminitinu	NS			0.079	0.016	Chew, 1965
	rat	Norway albino	NS			0.207	0.027	Chew, 1965
	rat	Norway	NS			0.241	0.02145	Chew, 1965
	rat	wood	NS			0.139	0.0181	Chew, 1965
	rat	wood	NS			0.11	0.0366	Chew, 1965
	rat	wood	NS			0.05	0.01	Latt, 1976
	rat		NS			0.1	0.02	Latt, 1976
	rat		NS		adult	0.25	0.02	Bruce, 1950
	rat		NS		adult	0.3	0.024	Bruce, 1950
	rat		NS			0.15	0.025	Latt, 1976
	rat		NS			0.2	0.03	Latt, 1976
	rat		NS		adult	0.225	0.031	Adolph, 1947
	rat		NS			0.25	0.035	Latt, 1976
Other laboratory mammals	cat		F			3	0.3	Arrington, 1978
	cat		F			3	0.3	Templeton, 1968
	cat	mixed	M	12	+7	4.5	0.1526	Taton et al., 1984
	cat	mixed	M	12	+42	4.3	0.1772	Taton et al., 1984
	cat	mixed	M	12	+21	4.4	0.1822	Taton et al., 1984

TABLE 5-1 (cont.)

Group	Species	Strain	Sex	No. of Animals	Age (days)	Weight (g/day)	Water	Reference
Other laboratory mammals (cont.)	cat	mixed	M	10	+63	4.2	0.184	Taton et al., 1984
	cat	mixed	M	5	+294	4.6	0.1863	Taton et al., 1984
	cat	mixed	M	6	+147	4.2	0.1877	Taton et al., 1984
	cat	mixed	M	9	+91	4.1	0.1942	Taton et al., 1984
	cat	mixed	M	8	+119	4.1	0.2001	Taton et al., 1984
	cat	mixed	M	6	+203	4.3	0.206	Taton et al., 1984
	cat	mixed	M	6	+245	4.5	0.207	Taton et al., 1984
	cat	mixed	M	5	+336	4.6	0.2199	Taton et al., 1984
	cat	mixed	M	6	+175	4.3	0.227	Taton et al., 1984
	cat		M			3	0.3	Arrington, 1978
	cat		M			3	0.3	Templeton, 1968
	cat		NS			4.49	0.32	Chew, 1965
	cat		NS			4.49	0.32	Chew, 1965
	dog		M&F	8	adult	24	0.8	Brown et al., 1984
	dog	beagle	F			11.5	0.3	Arrington, 1972
	dog	beagle	F			14.5	0.35	Templeton, 1968
	dog	mongrel	F	7	730 +	15.9	0.33128	Golob et al., 1977
	dog	mongrel	F	7	730 +	15.9	0.5669	Golob et al., 1977
	dog	beagle	M			15.5	0.3	Arrington, 1972
	dog	beagle	M			15.5	0.35	Templeton, 1968
	dog	greyhounds	NS	4		29.2	1.005	McKeever et al., 1985
	dog	greyhounds	NS	4		28.5	1.333	McKeever et al., 1985
	rabbit	Dutch	F	6	+185	2.32	0.174	Cizek, 1961
	rabbit	Dutch	F	6	+164	2.3	0.175	Cizek, 1961
	rabbit	Dutch	F	6	+70	2.13	0.185	Cizek, 1961
	rabbit	Dutch	F	6	+112	2.28	0.185	Cizek, 1961
	rabbit	Dutch	F	6	+143	2.29	0.185	Cizek, 1961
	rabbit	Dutch	F	12		2.571	0.187	Cizek, 1961
	rabbit	Dutch	F	12	+183	2.571	0.187	Cizek, 1961
	rabbit	Dutch	F	6	+91	2.19	0.195	Cizek, 1961
	rabbit	Dutch	F	12	+0	2.165	0.219	Cizek, 1961
	rabbit	Dutch	F	6	+07	1.79	0.22	Cizek, 1961
	rabbit	Dutch	F	6	+21	1.89	0.225	Cizek, 1961
	rabbit	Dutch	F	6	+35	1.96	0.226	Cizek, 1961
	rabbit	Dutch	F	6	+49	2.07	0.226	Cizek, 1961

TABLE 5-1 (cont.)

Group	Species	Strain	Sex	No. of Animals	Age (days)	Weight (ℓ/day)	Water	Reference
Other laboratory mammals (cont.)	rabbit	New Zealand white	F			5	0.3	Templeton, 1968
	rabbit		F			5	0.3	Arrington, 1972
	rabbit	Dutch	M	12	+183	2.002	0.166	Cizek, 1961
	rabbit	Dutch	M	6	+175	2.2	0.169	Cizek, 1961
	rabbit	Dutch	M	6	+154	2.23	0.17	Cizek, 1961
	rabbit	Dutch	M	6	+133	2.19	0.178	Cizek, 1961
	rabbit	Dutch	M	6	+70	2.22	0.185	Cizek, 1961
	rabbit	Dutch	M	6	+112	2.27	0.188	Cizek, 1961
	rabbit	Dutch	M	6	+91	2.23	0.19	Cizek, 1961
	rabbit	Dutch	M	12	+0	1.799	0.202	Cizek, 1961
	rabbit	Dutch	M	6	+49	2.16	0.21	Cizek, 1961
	rabbit	Dutch	M	6	+21	1.95	0.224	Cizek, 1961
	rabbit	Dutch	M	6	+35	2.09	0.225	Cizek, 1961
	rabbit	Dutch	M	6	+07	1.91	0.255	Cizek, 1961
	rabbit	New Zealand white	M			4.5	0.3	Templeton, 1968
	rabbit	New Zealand white	M	10		2.168	0.369	Cizek, 1961
	rabbit	M				4.5	0.3	Arrington, 1972
	rabbit	albino + CB	NS	11	adult	2.8	0.36	Bruce, 1950
	rabbit	albino & cross	NS	11		2.8	0.36	Lane-Peter et al., 1967
	rabbit	Dutch	NS	22	adult	2.1	0.319	Bruce, 1950
	rabbit	Dutch	NS	22		2.1	0.319	Lane-Peter et al., 1967
	rabbit	Himalayan	NS	16	adult	1.9	0.245	Bruce, 1950
	rabbit	Himalayan	NS	16		1.9	0.245	Lane-Peter et al., 1967
	rabbit	lop eared	NS	10	adult	3.5	0.446	Bruce, 1950
	rabbit	lop eared	NS	10		3.5	0.446	Lane-Peter et al., 1967
	rabbit	several	NS	59	adult	2.4	0.328	Bruce, 1950
	rabbit		NS		adult	2.5	0.16	Kennaway, 1943
	rabbit		NS	59		2.4	0.328	Lane-Peter et al., 1967
	rabbit		NS		adult	2.4	0.328	Lane-Peter et al., 1967

TABLE 5-1 (cont.)

Group	Species	Strain	Sex	No. of Animals	Age (days)	Weight (g/day)	Water	Reference
Other laboratory mammals (cont.)	rabbit	Dutch				2.14	0.201	Chew, 1965
	rabbit	Dutch				2.14	0.201	Chew, 1965
Livestock	cattle	Zebu	M&F			151	11.935	Chew, 1965
	cattle	Zebu	M&F			151	11.935	Chew, 1965
	cattle	holstein	F	7		3619	162	Atkeson and Warren, 1934
	cattle	holstein	F	7		3605	205	Atkeson and Warren, 1934
	cattle	holstein	F	7		3330	241.6	Atkeson and Warren, 1934
	cattle	holstein	F	7		3330	422	Atkeson and Warren, 1934
	cattle	jersey, holstein	F			427	17.92	Chew, 1965
	cattle	shorthorn	F			632	32.24	Chew, 1965
	cattle	HO,H,TL	M	12		313	43.1	Becker et al., 1985
	cattle	Kumauni	M			340	8.9	Chew, 1965
	cattle	steer	M			391	8.53	Chew, 1965
	chicken	brown leghorn	F	16		1.65	0.115	Howard, 1975
	chicken	brown leghorn	F	16		1.65	0.225	Howard, 1975
	chicken	white leghorn	M	4		2.257	0.614	Dunson and Buss, 1968
	chicken	white leghorn	M	6		1.603	0.119	Dunson et al., 1972
	chicken	white leghorn	NS	14	21	0.183	0.042	Dunson and Buss, 1968
	chicken	white leghorn	NS	4	28	0.2	0.043	Dunson and Buss, 1968
	chicken	white leghorn	NS	8	28	0.32	0.046	Dunson and Buss, 1968
	chicken	white leghorn	NS	15	84-196	1.532	0.13	Dunson and Buss, 1968
	cow		NS	20	18	44.11	1	Kertz et al., 1984
	cow		NS	20	11	44.43	1.14	Kertz et al., 1984
	cow		NS	20	25	47.2	1.18	Kertz et al., 1984
	cow		NS	20	31	52.65	2.59	Kertz et al., 1984
	horse	pony	M	4		202.5	8.7	Sufit et al., 1985
	horse		NS			611	76	Chew, 1965
	pig	P. angulatus	NS			23.6	2.2	Chew, 1965

TABLE 5-1 (cont.)

Group	Species	Strain	Sex	No. of Animals	Age (days)	Weight (ℓ/day)	Water	Reference
Livestock (cont.)	pig	white cross	NS	51	28	5.49	0.71	Brooks et al., 1984
	pig	white cross	NS	51	28	6.15	0.74	Brooks et al., 1984
	pig	white cross	NS	51	35	7.15	1.09	Brooks et al., 1984
	pig	white cross	NS	51	35	7.99	1.31	Brooks et al., 1984
	pig	white cross	NS	51	42	9.77	1.63	Brooks et al., 1984
	pig	white cross	NS	51	49	13.06	2.15	Brooks et al., 1984
	pig	white cross	NS	51	42	10.6	2.16	Brooks et al., 1984
	pig	white cross	NS	51	42	13.6	2.58	Brooks et al., 1984
	pig		NS			45.5	8.38	Chew, 1965
	pig		NS			149.9	8.7	Chew, 1965
	sheep	Corriedale	NS			52.7	2.06	Chew, 1965
	sheep	Merino	NS			29.9	1.17	Chew, 1965
Wildlife	camel	Dromedarius	NS			243	3.18	Chew, 1965
	deer	desert mule	NS			22.35	1.47	Chew, 1965
	deer	various	NS			34.95	2.84	Chew, 1965
	elephant	E. maximus	NS			3630	139	Chew, 1965
	ferret	domestic	F		adult	0.675	0.0875	Moody et al., 1985
	ferret	domestic	M		adult	2.025	0.0875	Moody et al., 1985
	lion		F	1		149	0.8	Green et al, 1984
	lion		M	1		91	1.07	Green et al, 1984
	lion		M	1		193	3.98	Green et al, 1984
	marmot	yellow-bellied	F	9	+14	3.81	0.134	Zatzman et al., 1984
	marmot	yellow-bellied	F	9	+28	3.86	0.182	Zatzman et al., 1984
	marmot	yellow-bellied	M	9	+175	5.32	0.034	Zatzman et al., 1984
	marmot	yellow-bellied	M	9	+168	5.33	0.041	Zatzman et al., 1984
	marmot	yellow-bellied	M	9	+154	5.29	0.063	Zatzman et al., 1984
	marmot	yellow-bellied	M	9	+140	5.46	0.089	Zatzman et al., 1984
	marmot	yellow-bellied	M	9	+126	5.5	0.117	Zatzman et al., 1984
	marmot	yellow-bellied	M	9	+112	5.45	0.145	Zatzman et al., 1984
	marmot	yellow-bellied	M	9	+98	5.39	0.187	Zatzman et al., 1984
	marmot	yellow-bellied	M	9	+42	4.62	0.191	Zatzman et al., 1984
	marmot	yellow-bellied	M	9	+56	4.76	0.211	Zatzman et al., 1984
	marmot	yellow-bellied	M	9	+84	5.19	0.228	Zatzman et al., 1984
	marmot	yellow-bellied	M	9	+70	4.95	0.231	Zatzman et al., 1984
	mink		M	4		1.613	0.175	Eriksson et al. 1984
	shrew	short-tailed	NS			0.0258	0.0125	Chew, 1965
	squirrel	C. leucurus	NS			0.085	0.0102	Chew, 1965
	squirrel	ground	NS			0.0925	0.0134	Chew, 1965

TABLE 5-1 (cont.)

Group	Species	Strain	Sex	No. of Animals	Age (days)	Weight (g/day)	Water	Reference
Wildlife (cont.)	vole	meadow	NS	7	(40-50)	0.045	0.00205	Laughlin et al., 1975
	vole	red-backed	NS			0.0279	0.025	Chew, 1965
	vole	tundra	NS			0.0426	0.0158	Chew, 1965
Birds	Br. mourning dov	Zenaidura mac.	NS			0.104	0.0103	Bartholomew and Cade, 1963
	Br. Budgerygah		NS			0.03	0.0025	Bartholomew and Cade, 1963
	Br. finch	house	NS			0.0206	0.0033	Bartholomew and Cade, 1963
	Br. pheasant	game	M&F	many	~20	0.112	0.029	Wise and Connan, 1979
	Br. pheasant	game	M&F	many	~40	0.325	0.061	Wise and Connan, 1979
	Br. pheasant	game	M&F	many	~60	0.625	0.075	Wise and Connan, 1979
	Br. pheasant	game	M&F	many	~80	0.93	0.078	Wise and Connan, 1979
	Br. quail	California	NS			0.139	0.0072	Bartholomew and Cade, 1963
	Br. sparrow	house	NS			0.0173	0.0057	Bartholomew and Cade, 1963
	Br. sparrow	Savannah	NS			0.0175	0.0102	Bartholomew and Cade, 1963
	Br. sparrow	Savannah	NS			0.019	0.0131	Bartholomew and Cade, 1963
	Br. sparrow	Savannah	NS			0.017	0.017	Bartholomew and Cade, 1963
	Br. sparrow	song	NS			0.0168	0.0035	Bartholomew and Cade, 1963
	Br. sparrow	song	NS			0.0182	0.0076	Bartholomew and Cade, 1963
	Br. sparrow	song	NS			0.0164	0.0086	Bartholomew and Cade, 1963
	Br. sparrow	white-throated	NS			0.023	0.0061	Bartholomew and Cade, 1963
	Br. sparrow	white-throated	NS			0.0265	0.0102	Bartholomew and Cade, 1963
	Br. towhee	Aberts	NS			0.0468	0.011	Bartholomew and Cade, 1963
	Br. towhee	brown	NS			0.0437	0.0069	Bartholomew and Cade, 1963
	Br. turkey	Amerine, Nichola	M	80	294,329	13.4	0.605	Parker et al., 1972

NS = Not specified

Templeton, 1968; Lane-Peter et al., 1967). Data on water intake that did not specify a body weight are excluded from this table. Statistical analyses of the data reported in Table 5-1 that are most relevant to risk assessment are given in Table 5-2 and illustrated in Figures 5-1 through 5-6.

More so than the data on minute volumes, the data on water consumption show marked intraspecies variability. The only points that are clear outliers, however, are the male marmots [just before hibernation (Zatzman et al., 1984)], which are excluded from the statistical analyses. As illustrated in Figure 5-2, a high correlation is apparent across all species in the allometric relationship of water consumption to body weight:

$$L = 0.11\ W^{0.7872} \qquad r^2 = 0.93 \qquad (5\text{-}2)$$

where L is water consumption and W is body weight in grams. Similar equations and high correlation coefficients are obtained by combining all data on primates (Figure 5-3: includes data on humans, baboons and monkeys), and laboratory mammals (Figure 5-4: includes data on gerbils, guinea pigs, hamsters, mice, rats, cats, dogs and rabbits). Intraspecies correlations are much lower. Only the allometric relationship for the dog, illustrated in Figure 5-5, has a reasonably high (0.87) correlation coefficient and differs remarkably from the general equation (Eq. 5-2). The studies on dogs by Brown et al. (1984), Golob et al. (1977) and McKeever et al. (1985) are well documented and reasonably consistent with the earlier values given in the secondary sources (Arrington, 1972; Templeton, 1968).

Water consumption for dogs and other species will vary greatly, depending on the moisture content of the chow. Allometric relationships to account for this dependency are given in Chapter 7.

TABLE 5-2

Species and Group Specific Allometric Relationships for Water Consumption in ℓ/day to Body Weight in kg (W)[a]

Animal Group	Allometric Equation	r^2	Figure
All species combined	$\ell = 0.11\ W^{0.7872}$	0.93	5-2
Primates	$\ell = 0.09\ W^{0.7945}$	0.95	5-3
Laboratory mammals	$\ell = 0.10\ W^{0.7377}$	0.88	5-4
Laboratory rodents	$\ell^{b} = 0.11\ W^{0.7482}$	0.68	NA
Gerbils	$\ell^{b} = 0.001W^{-0.546}$	-0.44	NA
Guinea pigs	$\ell^{b} = 0.11\ W^{0.1554}$	0.09	NA
Hamsters	$\ell^{b} = 0.06\ W^{0.6583}$	0.55	NA
Mice	$\ell^{b} = 0.04\ W^{0.4700}$	0.08	NA
Rats	$\ell^{b} = 0.06\ W^{0.4138}$	0.24	NA
Cats	$\ell^{a,b} = 0.76\ W^{-0.886}$	-0.36	NA
Dogs	$\ell^{b} = 0.004W^{1.6388}$	0.87	5-5
Rabbits	$\ell^{b} = 0.15\ W^{0.5161}$	0.22	NA
Chickens	$\ell = 0.13\ W^{0.7555}$	0.74	5-6

[a]If data are available on the diet (dry or moist) use equations on Table 7-2. This is particularly important for dogs and cats.

[b]Not recommended for derivng recommended values. Use equation for laboratory mammals.

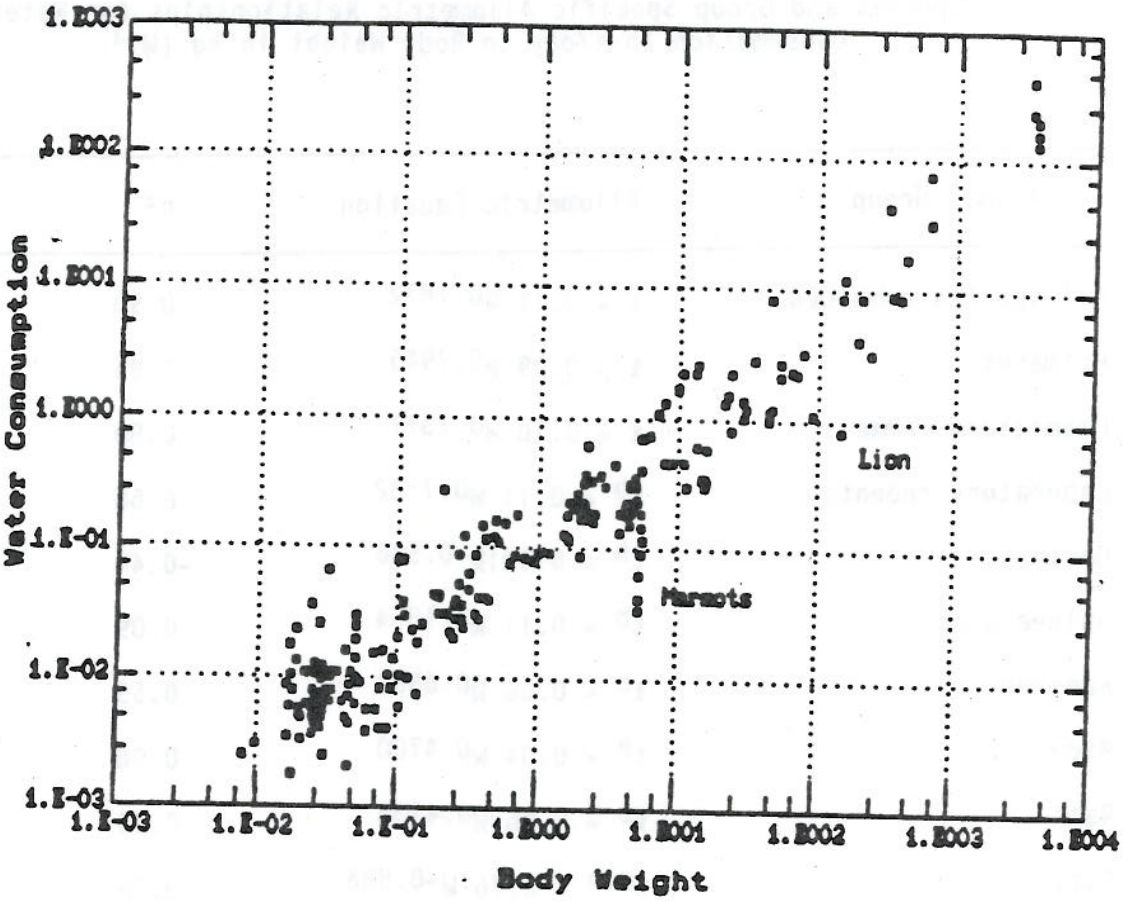


FIGURE 5-1

Plot of Water Consumption (ℓ/day) vs. Body Weight (kg) for All Species
(See Table 5-1 for points and references)

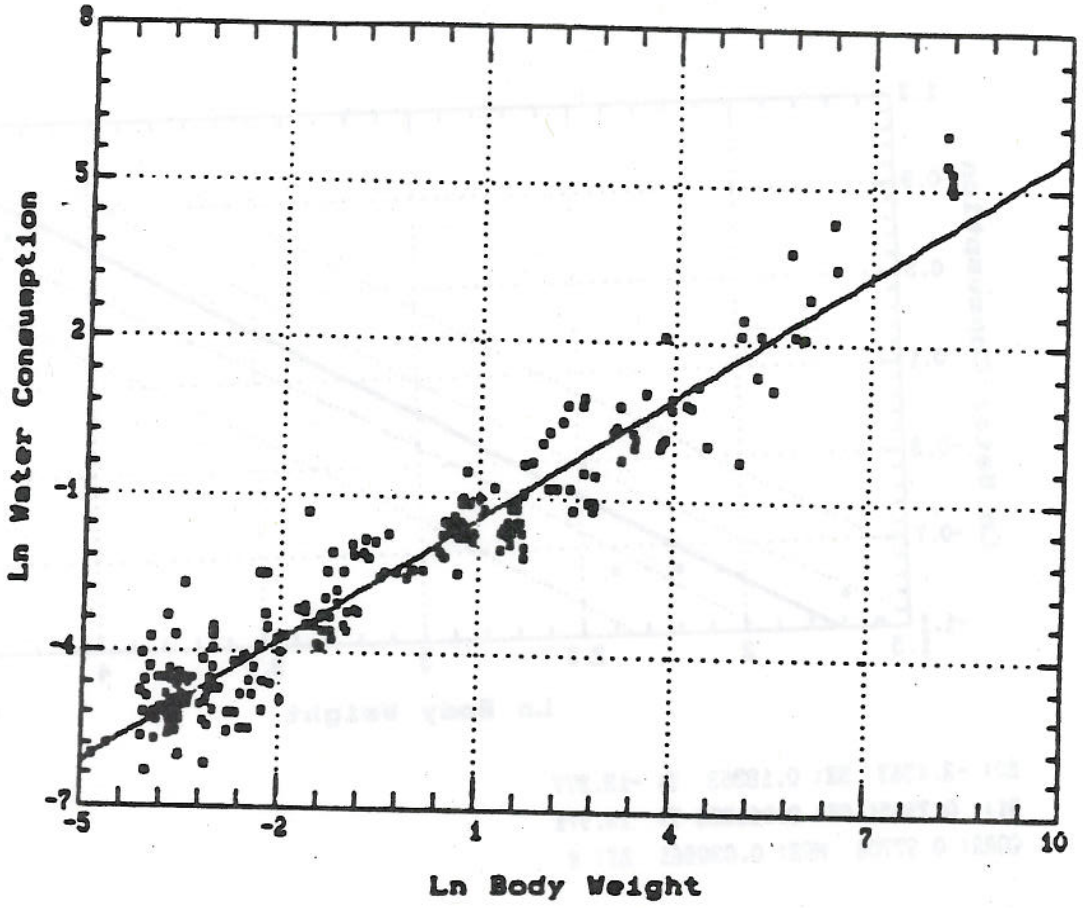
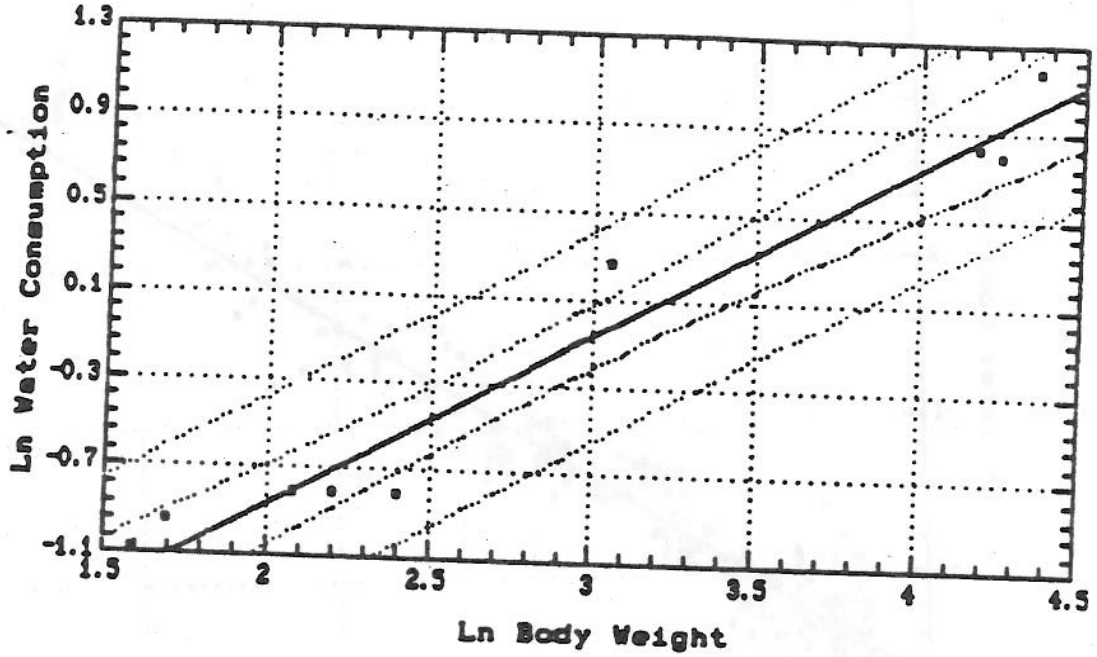


FIGURE 5-2

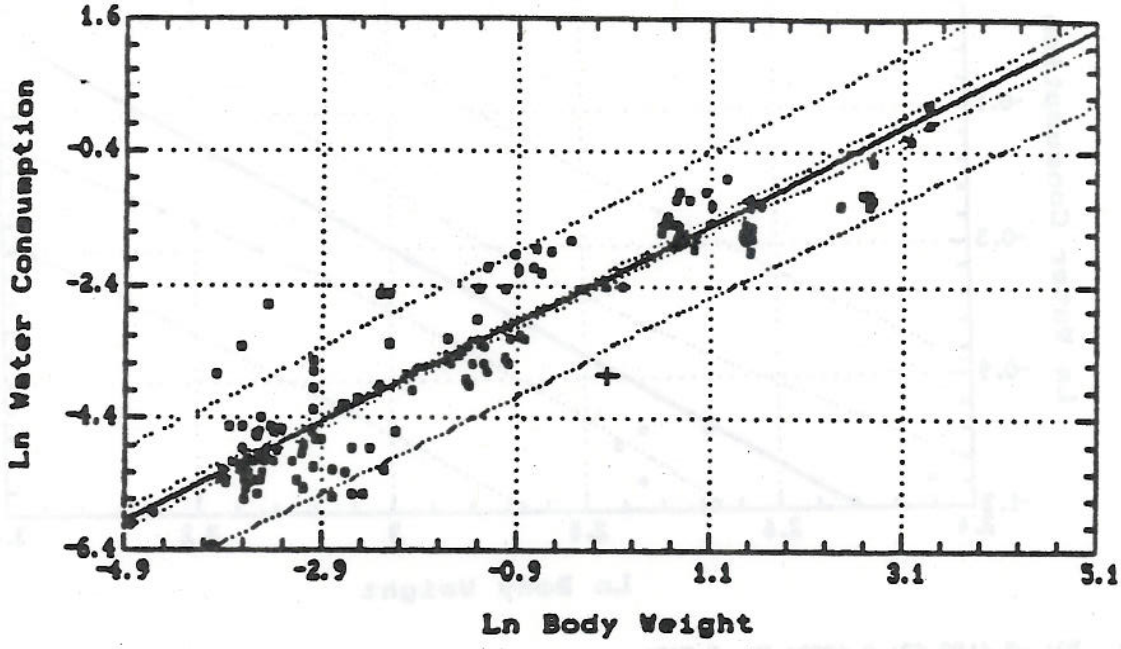
Allometric Relationship of Drinking Water (ℓ/day) to Body Weight (kg) for All Species, Except Marmots



B0: -2.4563 SE: 0.18363 T: -13.377
B1: 0.79451 SE: 0.061253 T: 12.971
CORR: 0.97704 MSE: 0.038961 DF: 8

FIGURE 5-3

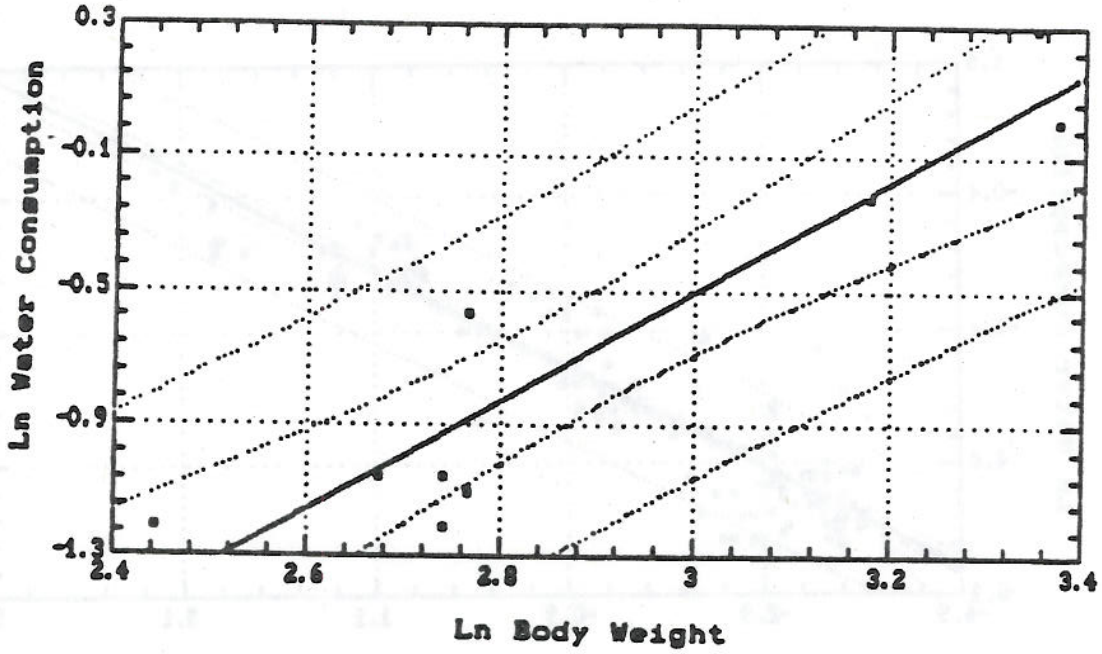
Allometric Relationship of Drinking Water (ℓ/day) to Body Weight (kg) for Primates



B0: -2.3151 SE: 0.04487 T: -51.597
B1: 0.73769 SE: 0.018525 T: 39.821
CORR: 0.94366 MSE: 0.30081 DF: 195

FIGURE 5-4

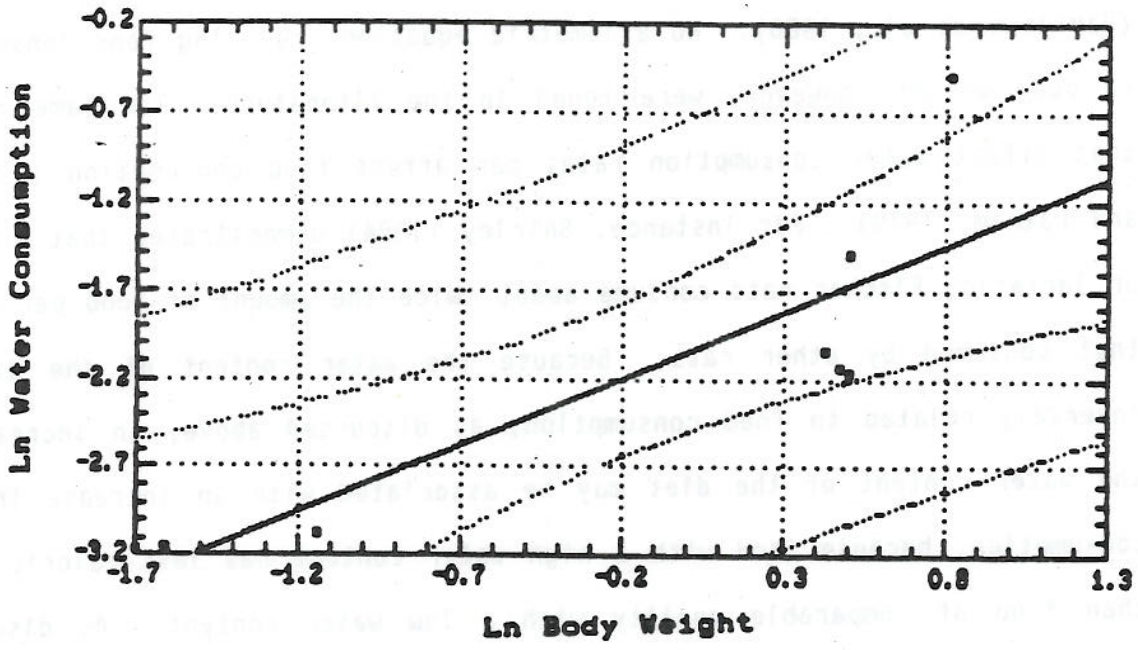
Allometric Relationship of Drinking Water (ℓ/day) to Body Weight (kg) for Laboratory Mammals (Gerbils, Guinea Pigs, Hamsters, Mice, Rats, Cats, Dogs and Rabbits).



B0: -5.4193 SE: 0.69934 T: -7.7491
B1: 1.6388 SE: 0.24042 T: 6.8165
CORR: 0.93224 MSE: 0.049184 DF: 7

FIGURE 5-5

Allometric Relationship of Drinking Water (ℓ/day) to Body Weight (kg) for Dogs



B0: -2.0497 SE: 0.18252 T: -11.23
B1: 0.75551 SE: 0.17874 T: 4.2268
CORR: 0.86522 MSE: 0.2545 DF: 6

FIGURE 5-6

Allometric Relationship of Drinking Water (ℓ/day) to Body Weight (kg) for Chickens

6. FOOD CONSUMPTION

Clear allometric relationships have been demonstrated between metabolic rate and body weight. These have been discussed at some length in both the classic literature (Brody, 1945; Benedict, 1938) and recent publications (Davidson et al., 1986). No allometric equations relating food consumption to body weight, however, were found in the literature. The same factors that affect water consumption rates can affect food consumption (Blundell and Latham, 1979). For instance, Shirley (1984) demonstrated that pregnant or lactating Fischer rats consume about twice the amount of food per day as that consumed by other rats. Because the water content of the diet is inversely related to food consumption, as discussed above, an increase in the water content of the diet may be associated with an increase in food consumption, because food with a high water content has less caloric value than food of comparable quality with a low water content. As discussed below, this may explain an apparent anomalous relationship seen in the food consumption data on cats. Many other examples are available, which suggest that the food consumption of animals will increase as the caloric content of the food decreases (Brody, 1945).

Data on food consumption for a wide variety of animals are summarized in Table 6-1 and plotted in Figure 6-1. Some of the data points were not considered in the derivation of recommended values because they are atypical for the species or other species of similar body weights. The marmots just before hibernation, labeled in Figure 6-1, show a marked decrease in food consumption as well as the decrease in water consumption noted above. One group of cattle from a study by Kertz et al. (1984) is omitted because of an atypically low food consumption not seen in other groups of cattle from the

TABLE 6-1

Food Consumption Data on Various Animal Groups

Group	Species	Strain	Sex	No. of Animals	Age (days)	Weight (kg)	Food (kg/day)	Reference
Primates	human		F		adult	58	0.871	Snyder et al., 1981
	human		M		adult	70	1.305	Snyder et al., 1981
	human		M		10 years	32	0.84	Snyder et al., 1981
	monkey	rhesus	F			8	0.20	Templeton, 1968
	monkey	rhesus	F			9	0.20	Arrington, 1972
	monkey	rhesus	M			11	0.20	Arrington, 1972
	monkey	rhesus	M			11	0.20	Templeton, 1968
Laboratory rodents	gerbil	Mongolian	M&F	20	weaning	0.048	0.005	Arrington, 1968
	gerbil	Mongolian	M&F	16-20	adult	0.0587	0.00524	McManus, 1972
	gerbil	Mongolian	M&F	20	[215]	0.06125	0.00478	Harriman, 1969a
	gerbil	Mongolian	F			0.075	0.008	Templeton, 1968
	gerbil	Mongolian	M			0.085	0.008	Templeton, 1968
	gerbil		F			0.075	0.008	Arrington, 1972
	gerbil		M			0.085	0.008	Arrington, 1972
	guinea pig	albino short-hair	M	5	10	0.2	0.017	Hirsch, 1973
	guinea pig	albino short-hair	M	5	30	0.11	0.025	Hirsch, 1973
	guinea pig	albino short-hair	M	5	20	0.27	0.025	Hirsch, 1973
	guinea pig	albino short-hair	M	5	40	0.415	0.028	Hirsch, 1973
	guinea pig	albino short-hair	M	5	50	0.48	0.031	Hirsch, 1973
	guinea pig	albino short-hair	M	5	60	0.52	0.032	Hirsch, 1973
	guinea pig	albino short-hair	M	5	70	0.58	0.035	Hirsch, 1973
	guinea pig	Duncan-Hartley	F	45	+0	0.2035	0.0265	Shelton, 1971
	guinea pig	Duncan-Hartley	F	45	+35	0.4425	0.0265	Shelton, 1971
	guinea pig	Duncan-Hartley		15	+0	0.204	0.0285	Shelton, 1971
	guinea pig		F			1.025	0.045	Arrington, 1972
	guinea pig		M			1.2	0.045	Arrington, 1972
	guinea pig		F			1	0.045	Templeton, 1968
	guinea pig		M			1.2	0.045	Templeton, 1968
	hamster	Golden	M&F	12	+42	0.07475	0.0069	Banta et al., 1975
	hamster	Golden	M&F	22	weaning	0.0417	0.00845	Arrington, 1968
	hamster	Golden	M&F	22	weaning	0.041	0.00845	Arrington, 1968
	hamster	Syrian	F	10	+0-+42	0.0474	0.0051	Arrington et al., 1966
	hamster	Syrian	F	10	+0-+42	0.0633	0.0067	Arrington et al., 1966
	hamster	Syrian	F	10	+0-+42	0.0679	0.0067	Arrington et al., 1966
	hamster	Syrian	F	10	+0-+42	0.06735	0.0069	Arrington et al., 1966
	hamster	Syrian	F			0.0545	0.011	Templeton, 1968

TABLE 6-1 (cont.)

Group	Species	Strain	Sex	No. of Animals	Age (days)	Weight (kg)	Food (kg/day)	Reference
Laboratory rodents (cont.)	hamster	Syrian	F			0.1175	0.011	Arrington, 1972
	hamster	Syrian	M	8	+0-+42	0.05785	0.0055	Arrington et al., 1966
	hamster	Syrian	M	8	+0-+42	0.0652	0.0062	Arrington et al., 1966
	hamster	Syrian	M	8	+0-+42	0.0679	0.0065	Arrington et al., 1966
	hamster	Syrian	M	8	+0-+42	0.0698	0.0067	Arrington et al., 1966
	hamster	Syrian	M			0.05125	0.011	Templeton, 1968
	hamster	Syrian	M			0.1075	0.011	Arrington, 1972
	mouse	Aston	F	13	(80-90)	0.0302	0.0045	Richard and Trayhurn, 1985
	mouse	A/J	F	15	(100-110)	0.0209	0.0049	Kutscher, 1974
	mouse	A/J	M	15	(100-110)	0.0252	0.0057	Kutscher, 1974
	mouse	BALB/c	F	48	+0-7	0.0166	0.00309	Oller et al., 1985
	mouse	BALB/c	F	48	+84-91	0.0219	0.0031	Oller et al., 1985
	mouse	BALB/c	F	48	+56-63	0.02	0.00316	Oller et al., 1985
	mouse	BALB/c	F	48	+35-42	0.0189	0.00344	Oller et al., 1985
	mouse	BALB/c	F	48	+14-21	0.018	0.00351	Oller et al., 1985
	mouse	BALB/c	F	15	(100-110)	0.0201	0.0059	Kutscher, 1974
	mouse	BALB/c	M	48	+0-7	0.0197	0.00327	Oller et al., 1985
	mouse	BALB/c	M	48	+0-7	0.0197	0.00327	Oller et al., 1985
	mouse	BALB/c	M	48	+35-42	0.0242	0.00346	Oller et al., 1985
	mouse	BALB/c	F	15	(100-110)	0.0201	0.0059	Kutscher, 1974
	mouse	BALB/c	M	48	+0-7	0.0197	0.00327	Oller et al., 1985
	mouse	BALB/c	M	48	+0-7	0.0197	0.00327	Oller et al., 1985
	mouse	BALB/c	M	48	+35-42	0.0242	0.00346	Oller et al., 1985
	mouse	BALB/c	M	48	+84-91	0.0285	0.00349	Oller et al., 1985
	mouse	BALB/c	M	48	+56-63	0.0256	0.0036	Oller et al., 1985
	mouse	BALB/c	M	48	+14-21	0.0224	0.00379	Oller et al., 1985
	mouse	BALB/c	M	15	(100-110)	0.027	0.0068	Kutscher, 1974
	mouse	B6C3F1	F	48	+0-7	0.0163	0.00311	Oller et al., 1985
	mouse	B6C3F1	F	48	+56-63	0.0204	0.0034	Oller et al., 1985
	mouse	B6C3F1	F	48	+84-93	0.0214	0.00344	Oller et al., 1985
	mouse	B6C3F1	F	48	+35-42	0.0195	0.00356	Oller et al., 1985
	mouse	B6C3F1	F	48	+14-21	0.018	0.0037	Oller et al., 1985
	mouse	B6C3F1	M	48	+0-7	0.0196	0.00339	Oller et al., 1985
	mouse	B6C3F1	M	48	+35-42	0.0249	0.00364	Oller et al., 1985
	mouse	B6C3F1	M	48	+56-63	0.0269	0.00366	Oller et al., 1985

TABLE 6-1 (cont.)

Group	Species	Strain	Sex	No. of Animals	Age (days)	Weight (kg)	Food (kg/day)	Reference
Laboratory rodents (cont.)	mouse	B6C3F1	M	48	+84-91	0.0287	0.00367	Oller et al., 1985
	mouse	B6C3F1	M	48	+14-21	0.023	0.0039	Oller et al., 1985
	mouse	CBA	F	15	(100-110)	0.0259	0.0092	Kutscher, 1974
	mouse	CBA	M	15	(100-110)	0.031	0.008	Kutscher, 1974
	mouse	Charles River	M	7	adult	0.0453	0.0055	DeLacey et al., 1975
	mouse	Charles River	M	8	adult	0.0424	0.00566	DeLacey et al., 1975
	mouse	Crl,CD-1,CR,BR	F	40	182	0.03075	0.0052	Chvedoff et al, 1980
	mouse	Crl,CD-1,CR,BR	F	40	364	0.03475	0.00635	Chvedoff et al, 1980
	mouse	Crl,CD-1,CR,BR	M	40	546	0.04475	0.00565	Chvedoff et al, 1980
	mouse	Crl,CD-1,CR,BR	M	40	182	0.0405	0.0059	Chvedoff et al, 1980
	mouse	Crl,CD-1,CR,BR	M	40	364	0.0455	0.006	Chvedoff et al, 1980
	mouse	Crl,CD-1,1CR,BR	F	40	546	0.03375	0.0054	Chvedoff et al, 1980
	mouse	C3H	F	15	(100-110)	0.0228	0.0057	Kutscher, 1974
	mouse	C3H	M	15	(100-110)	0.0264	0.0062	Kutscher, 1974
	mouse	C57B1	N	13-16	30-71	0.02335	0.0029	Hoover-Plow and Nelson, 1985
	mouse	C57	F	15	(100-110)	0.0223	0.0064	Kutscher, 1974
	mouse	C57	M	15	(100-110)	0.0275	0.0072	Kutscher, 1974
	mouse	DBA	F	15	(100-110)	0.0247	0.0063	Kutscher, 1974
	mouse	DBA	M	15	(100-110)	0.0309	0.0085	Kutscher, 1974
	mouse	I	N	12-16	30-71	0.01915	0.0028	Hoover-Plow and Nelson, 1985
	mouse	striped field	N	10-15		0.0206	0.003	Drozdz, 1968
	mouse	striped field	N	10-15		0.0223	0.00346	Drozdz, 1968
	mouse	SWR	F	15	(100-110)	0.0217	0.0056	Kutscher, 1974
	mouse	SWR	M	15	(100-110)	0.0286	0.0065	Kutscher, 1974
	mouse	white	F	8	70	0.0248	0.0059	Chew and Hinegardner, 1957
	mouse	white	F	8	105-120	0.0282	0.006	Chew and Hinegardner, 1957
	mouse	white	F	8	396	0.0335	0.0066	Chew and Hinegardner, 1957
	mouse	white	M	8	70	0.0297	0.0065	Chew and Hinegardner, 1957
	mouse	white	M	8	105-120	0.0324	0.0068	Chew and Hinegardner, 1957
	mouse	white	M	8	396	0.0369	0.0073	Chew and Hinegardner, 1957
	mouse	wood	N			0.02	0.0046	Chmiel and Harrison, 1981
	mouse	yel-neck field	N	10-15		0.0288	0.00206	Drozdz, 1968
	mouse	yel-neck field	N	10-15		0.0279	0.00212	Drozdz, 1968
	mouse	yel-neck field	N	10-15		0.0241	0.0035	Drozdz, 1968

TABLE 6-1 (cont.)

Group	Species	Strain	Sex	No. of Animals	Age (days)	Weight (kg)	Food (kg/day)	Reference
Laboratory rodents (cont.)	mouse		F			0.0265	0.0045	Arrington, 1972
	mouse		M			0.03	0.0045	Arrington, 1972
	rat	albino	M	14	(80-105)	0.2891	0.0217	Moyer, K.E., 1966
	rat	Fischer 344	F	120	98-105	0.16695	0.0149	Morrissey and Norred, 1984
	rat	kangaroo	M&F	4		0.105	0.0074	Bailey, 1923
	rat	kangaroo	M&F	4		0.105	0.0074	Bailey, 1923
	rat	king	M	75	+11	0.094	0.00945	Peters and Harper, 1985
	rat	Long-Evans	M	54	913	0.55	0.0208	Holloszy and Smith, 1986
	rat	Long-Evans	M	54	760	0.59	0.024	Holloszy and Smith, 1986
	rat	Long-Evans	M	54	608	0.575	0.0247	Holloszy and Smith, 1986
	rat	Long-Evans	M	54	456	0.53	0.0268	Holloszy and Smith, 1986
	rat	Long-Evans	M	54	304	0.45	0.0271	Holloszy and Smith, 1986
	rat	Sprague-Dawley	F	13	0(1)	0.2568	0.0122	Shirley, 1984
	rat	Sprague-Dawley	F	13	8(pl)	0.2525	0.0164	Shirley, 1984
	rat	Sprague-Dawley	F	13	21(g)	0.3418	0.0178	Shirley, 1984
	rat	Sprague-Dawley	F	13	7(pl)	0.2557	0.0182	Shirley, 1984
	rat	Sprague-Dawley	F	13	6(g)	0.2498	0.0188	Shirley, 1984
	rat	Sprague-Dawley	F	13	4(pl)	0.2559	0.0189	Shirley, 1984
	rat	Sprague-Dawley	F	13	3(pl)	0.2612	0.0192	Shirley, 1984
	rat	Sprague-Dawley	F	13	6(pl)	0.2585	0.0194	Shirley, 1984
	rat	Sprague-Dawley	F	13	3(g)	0.2466	0.0195	Shirley, 1984
	rat	Sprague-Dawley	F	13	9(g)	0.2547	0.0202	Shirley, 1984
	rat	Sprague-Dawley	F	13	5(pl)	0.2607	0.0205	Shirley, 1984
	rat	Sprague-Dawley	F	13	12(g)	0.2638	0.0212	Shirley, 1984
	rat	Sprague-Dawley	F	13	15(g)	0.2743	0.0215	Shirley, 1984
	rat	Sprague-Dawley	F	13	2(pl)	0.2738	0.0231	Shirley, 1984
	rat	Sprague-Dawley	F	13	18(g)	0.307	0.0259	Shirley, 1984
	rat	Sprague-Dawley	F	13	2(l)	0.262	0.0271	Shirley, 1984
	rat	Sprague-Dawley	F	13	3(l)	0.2576	0.0342	Shirley, 1984
	rat	Sprague-Dawley	F	13	5(l)	0.2735	0.0431	Shirley, 1984
	rat	Sprague-Dawley	F	13	6(l)	0.2743	0.0449	Shirley, 1984
	rat	Sprague-Dawley	F	13	1(pl)	0.2941	0.0481	Shirley, 1984
	rat	Sprague-Dawley	F	13	8(l)	0.2763	0.049	Shirley, 1984
	rat	Sprague-Dawley	F	13	9(l)	0.28	0.0505	Shirley, 1984
	rat	Sprague-Dawley	F	13	11(l)	0.2838	0.0525	Shirley, 1984
	rat	Sprague-Dawley	F	13	12(l)	0.2818	0.0619	Shirley, 1984
	rat	Sprague-Dawley	F	13	14(l)	0.2945	0.0663	Shirley, 1984
	rat	Sprague-Dawley	F	13	15(l)	0.2918	0.0702	Shirley, 1984
	rat	Sprague-Dawley	F	13	17(l)	0.2916	0.071	Shirley, 1984

TABLE 6-1 (cont.)

Group	Species	Strain	Sex	No. of Animals	Age (days)	Weight (kg)	Food (kg/day)	Reference
Laboratory rodents (cont.)	rat	Sprague-Dawley	F	13	18(1)	0.2896	0.0711	Shirley, 1984
	rat	Sprague-Dawley	F	13	20(1)	0.2941	0.0855	Shirley, 1984
	rat	Sprague-Dawley	F	13	21(1)	0.2917	0.0944	Shirley, 1984
	rat	Sprague-Dawley	M	10	24-52	0.05	0.008	Delorme and Wojcik, 1982
	rat	Sprague-Dawley	M	10	24-52	0.05	0.012	Delorme and Wojcik, 1982
	rat	Sprague-Dawley	M	10	24-52	0.05	0.0136	Delorme and Wojcik, 1982
	rat	Sprague-Dawley	M	10	24-52	0.05	0.0143	Delorme and Wojcik, 1982
	rat	Sprague-Dawley	M	8	-180	0.38	0.032	Grunberg et al., 1984
	rat	Sprague-Dawley	M	8	+6	0.422	0.033	Grunberg et al., 1984
	rat	Sprague-Dawley	M	8	+12	0.442	0.036	Grunberg et al., 1984
	rat		F			0.29	0.0135	Arrington, 1972
	rat		F	1	adult	0.26	0.019	Bruce, 1950
	rat		F	1	adult	0.36	0.025	Bruce, 1950
	rat		F	1	adult	0.26	0.027	Bruce, 1950
	rat		F	1	adult	0.275	0.08	Bruce, 1950
	rat		F	1	adult	0.36	0.08	Bruce, 1950
	rat		M			0.375	0.0135	Arrington, 1972
	rat		M		adult	0.225	0.011	Adolph, 1947
Other laboratory mammals	cat	mixed	M&F		105	1.207	0.161	Waterhouse and Carver, 1966
	cat	mixed	M&F		270	2.228	0.192	Waterhouse and Carver, 1966
	cat	mixed	M&F		135	1.577	0.206	Waterhouse and Carver, 1966
	cat	mixed	M&F		365	2.574	0.211	Waterhouse and Carver, 1966
	cat	mixed	M&F		165	1.718	0.216	Waterhouse and Carver, 1966
	cat	mixed	M&F		225	2.175	0.218	Waterhouse and Carver, 1966
	cat	mixed	M&F		195	1.893	0.219	Waterhouse and Carver, 1966
	cat	mixed	M&F		395	2.781	0.223	Waterhouse and Carver, 1966
	cat	mixed	M	12	+7	4.5	0.0549	Taton et al., 1984
	cat	mixed	M	12	+42	4.3	0.0555	Taton et al., 1984
	cat	mixed	M	10	+63	4.2	0.063	Taton et al., 1984
	cat	mixed	M	5	+294	4.6	0.0676	Taton et al., 1984
	cat	mixed	M	5	+336	4.6	0.0681	Taton et al., 1984
	cat	mixed	M	5	+336	4.6	0.0681	Taton et al., 1984
	cat	mixed	M	8	+119	4.1	0.0697	Taton et al., 1984
	cat	mixed	M	6	+147	4.2	0.0727	Taton et al., 1984
	cat	mixed	M	6	+245	4.5	0.0738	Taton et al., 1984
	cat	mixed	M	12	+21	4.4	0.0739	Taton et al., 1984
	cat	mixed	M	9	+91	4.1	0.0742	Taton et al., 1984
	cat	mixed	M	6	+203	4.3	0.0808	Taton et al., 1984
	cat	mixed	M	6	+175	4.3	0.0867	Taton et al., 1984

TABLE 6-1 (cont.)

Group	Species	Strain	Sex	No. of Animals	Age (days)	Weight (kg)	Food (kg/day)	Reference
Other laboratory mammals (cont.)	cat		M&F	8		0.8843	0.04275	Smalley et al., 1985
	cat		F			3	0.175	Arrington, 1972
	cat		F			3	0.175	Arrington, 1978
	cat		F			3	0.175	Templeton, 1968
	cat		M			3	0.175	Arrington, 1972
	cat		M			3	0.175	Arrington, 1978
	cat		M			3	0.175	Templeton, 1968
	dog	beagle	F			11.5	0.40	Arrington, 1972
	dog	beagle	F			14.5	0.40	Templeton, 1968
	dog	beagle	M			15.5	0.40	Arrington, 1972
	dog	beagle	M			15.5	0.40	Templeton, 1968
	dog		M&F	8	adult	24	0.36	Brown et al., 1984
	dog		M	1		5.82	1.266	Cowgill, 1928
	rabbit	Dutch	M&F	24	(42-49)	0.881	0.0496	Arrington et al., 1974
	rabbit	Dutch	M&F	24	(78-85)	1.4	0.0496	Arrington et al., 1974
	rabbit	Dutch	F	6	+185	2.32	0.063	Cizek, 1961
	rabbit	Dutch	F	6	+164	2.3	0.064	Cizek, 1961
	rabbit	Dutch	F	6	+70	2.13	0.071	Cizek, 1961
	rabbit	Dutch	F	6	+143	2.29	0.072	Cizek, 1961
	rabbit	Dutch	F	6	+112	2.28	0.073	Cizek, 1961
	rabbit	Dutch	F	6	+91	2.19	0.078	Cizek, 1961
	rabbit	Dutch	F	12	+183	2.571	0.0802	Cizek, 1961
	rabbit	Dutch	F	12		2.571	0.0802	Cizek, 1961
	rabbit	Dutch	F	12	+0	2.165	0.0833	Cizek, 1961
	rabbit	Dutch	F	6	+35	1.96	0.084	Cizek, 1961
	rabbit	Dutch	F	6	+49	2.07	0.084	Cizek, 1961
	rabbit	Dutch	F	6	+21	1.89	0.088	Cizek, 1961
	rabbit	Dutch	F	6	+7	1.79	0.09	Cizek, 1961
	rabbit	Dutch	M	6	+175	2.2	0.059	Cizek, 1961
	rabbit	Dutch	M	6	+133	2.19	0.063	Cizek, 1961

TABLE 6-1 (cont.)

Group	Species	Strain	Sex	No. of Animals	Age (days)	Weight (kg)	Food (kg/day)	Reference
Other laboratory mammals (cont.)	rabbit	Dutch	M	6	+154	2.23	0.063	Cizek, 1961
	rabbit	Dutch	M	12	+183	2.02	0.0632	Cizek, 1961
	rabbit	Dutch	M	6	+91	2.23	0.069	Cizek, 1961
	rabbit	Dutch	M	6	+112	2.27	0.075	Cizek, 1961
	rabbit	Dutch	M	6	+70	2.22	0.077	Cizek, 1961
	rabbit	Dutch	M	6	+35	2.09	0.078	Cizek, 1961
	rabbit	Dutch	M	6	+49	2.16	0.078	Cizek, 1961
	rabbit	Dutch	M	12	+0	1.799	0.0792	Cizek, 1961
	rabbit	Dutch	M	6	+21	1.95	0.084	Cizek, 1961
	rabbit	Dutch	M	6	+7	1.91	0.087	Cizek, 1961
	rabbit	New Zealand white	F			5	0.15	Templeton, 1968
	rabbit	New Zealand white	M			4.5	0.15	Templeton, 1968
	rabbit		F			5	0.15	Arrington, 1972
	rabbit		M			4.5	0.15	Arrington, 1972
	rabbit		M			4.5	0.15	Arrington, 1978
	rabbit		M		-42	1	0.115	Davidson and Spreadbury, 1975
	rabbit		M		53	1.5	0.143	Davidson and Spreadbury, 1975
	rabbit		M		-63	2	0.168	Davidson and Spreadbury, 1975
Livestock	cattle	MO,M,TL	M	12		313	8.20	Becker et al., 1985
	cattle	Holstein	F	7		3619	131	Atkeson and Warren, 1934
	cattle	Holstein	F	7		3330	133.70	Atkeson and Warren, 1934
	cattle	Holstein	F	7		3330	185	Atkeson and Warren, 1934
	cattle	Holstein	F	7		3605	29.10	Atkeson and Warren, 1934
	cattle	several	M	many	(98-126)	94	3.04	Taylor et al., 1986
	cattle	several	M	many	(126-154)	111	4.14	Taylor et al., 1986
	cattle	several	M	many	(154-162)	133	5.29	Taylor et al., 1986
	cattle	several	M	many	(162-210)	159	6.25	Taylor et al., 1986
	cattle	several	M	many	(210-238)	184	6.94	Taylor et al., 1986
	cattle	several	M	many	(238-266)	210	7.32	Taylor et al., 1986
	cattle	several	M	many	(266-294)	233	7.64	Taylor et al., 1986
	cattle	several	M	many	(229-322)	256	8	Taylor et al., 1986
	cattle	several	M	many	(322-350)	278	8.25	Taylor et al., 1986
	cattle	several	M	many	(350-378)	299	8.50	Taylor et al., 1986
	cattle	several	M	many	(378-406)	319	8.64	Taylor et al., 1986
	cattle	several	M	many	(406-434)	338	8.86	Taylor et al., 1986
	cattle	several	M	many	(434-462)	358	9	Taylor et al., 1986
	cattle	several	M	many	(462-490)	376	9.04	Taylor et al., 1986

TABLE 6-1 (cont.)

Group	Species	Strain	Sex	No. of Animals	Age (days)	Weight (kg)	Food (kg/day)	Reference
Livestock (cont.)	cattle		N	20	18	44.11	0.14	Kertz et al., 1984
	cattle		N	20	25	47.2	0.50	Kertz et al., 1984
	cattle		N	20	31	52.65	1.01	Kertz et al., 1984
	cattle		N			27	3.825	Lane-Peter et al., 1967
	cattle		N			36	4.30	Lane-Peter et al., 1967
	cattle		N			45	5.05	Lane-Peter et al., 1967
	cattle		N			55	5.40	Lane-Peter et al., 1967
	chicken	Ross broiler	M	3	7	0.164	0.0157	Prescott et al., 1985
	chicken	Ross broiler	M	3	14	0.334	0.0207	Prescott et al., 1985
	chicken	Ross broiler	M	3	21	0.765	0.0714	Prescott et al., 1985
	chicken	Ross broiler	M	3	28	1.155	0.1057	Prescott et al., 1985
	chicken	Ross broiler	M	3	35	1.539	0.1243	Prescott et al., 1985
	chicken	Ross broiler	M	3	42	1.778	0.1471	Prescott et al., 1985
	chicken	Ross broiler	M	3	49	2.334	0.1629	Prescott et al., 1985
	chicken	Ross broiler	M	3	63	3.254	0.2129	Prescott et al., 1985
	chicken	Ross broiler	M	3	77	3.934	0.2671	Prescott et al., 1985
	chicken	Ross broiler	M	3	91	4.73	0.2429	Prescott et al., 1985
	chicken	Ross broiler	M	3	105	5.46	0.2789	Prescott et al., 1985
	chicken	Ross broiler	M	3	119	5.758	0.2929	Prescott et al., 1985
	chicken	Ross broiler	M	3	140	6.49	0.3048	Prescott et al., 1985
	chicken	Ross broiler	M	2	161	6.5	0.3905	Prescott et al., 1985
	pig	cross-bred	M	24		31.3	1.4415	Asche et al., 1986
	pig	white cross	N	51	28	5.49	0.164	Brooks et al., 1984
	pig	white cross	N	51	28	6.15	0.187	Brooks et al., 1984
	pig	white cross	N	51	35	7.15	0.34	Brooks et al., 1984
	pig	white cross	N	51	35	7.99	0.357	Brooks et al., 1984
	pig	white cross	N	51	42	9.77	0.567	Brooks et al., 1984
	pig	white cross	N	51	42	10.6	0.594	Brooks et al., 1984
	pig	white cross	N	51	42	13.6	0.704	Brooks et al., 1984
	pig	white cross	N	51	49	13.06	0.762	Brooks et al., 1984
	sheep		N		newly weaned	31.5	0.575	Lane-Peter et al., 1967
	sheep		N		growing	45	0.75	Lane-Peter et al., 1967
	sheep		N		growing	63	0.85	Lane-Peter et al., 1967
Wildlife	ferret	domestic	F		adult	0.675	0.168	Moody et al., 1985
	ferret	domestic	M		adult	2.025	0.168	Moody et al., 1985
	hyena		F	1		71	2.44	Green et al., 1984
	hyena		F	1		58	4.88	Green et al., 1984
	hyena		M	1		38	4.05	Green et al., 1984

TABLE 6-1 (cont.)

Group	Species	Strain	Sex	No. of Animals	Age (days)	Weight (kg)	Food (kg/day)	Reference
Wildlife (cont.)	koala		M&F			9.2	0.5105	Nagy and Martin, 1985
	lion		F	1		149	6.12	Green et al., 1984
	lion		M	1		193	5.06	Green et al., 1984
	lion		M	1		91	6.53	Green et al., 1984
	marmot	yellow-bellied	F	9	+14	3.81	0.0799	Zatzman et al., 1984
	marmot	yellow-bellied	F	9	+28	3.86	0.1012	Zatzman et al., 1984
	marmot	yellow-bellied	M	9	+175	5.32	0.0198	Zatzman et al., 1984
	marmot	yellow-bellied	M	9	+168	5.33	0.0329	Zatzman et al., 1984
	marmot	yellow-bellied	M	9	+154	5.29	0.057	Zatzman et al., 1984
	marmot	yellow-bellied	M	9	+140	5.46	0.057	Zatzman et al., 1984
	marmot	yellow-bellied	M	9	+126	5.5	0.0816	Zatzman et al., 1984
	marmot	yellow-bellied	M	9	+112	5.45	0.0928	Zatzman et al., 1984
	marmot	yellow-bellied	M	9	+98	5.39	0.1049	Zatzman et al., 1984
	marmot	yellow-bellied	M	9	+42	4.62	0.1086	Zatzman et al., 1984
	marmot	yellow-bellied	M	9	+56	4.76	0.1178	Zatzman et al., 1984
	marmot	yellow-bellied	M	9	+70	4.95	0.122	Zatzman et al., 1984
	marmot	yellow-bellied	M	9	+84	5.19	0.122	Zatzman et al., 1984
	mink		M	4		1.613	0.042	Eriksson et al., 1984
	nutria		M		adult	8	1.35	Lane-Peter et al., 1967
	shrew	common	M			0.008	0.0008	Chmiel and Harrison, 1981
	vole	bank	M	10-15		0.0227	0.00192	Drozdz, 1968
	vole	bank	M	10-15		0.0231	0.00226	Drozdz, 1968
	vole	bank	M	10-15		0.0229	0.0034	Drozdz, 1968
	vole	bank	M			0.02	0.0055	Chmiel and Harrison, 1981
	vole	bank	M	0-15		0.0224	0.00183	Drozdz, 1968
	vole	common	M	0-15		0.0276	0.00424	Drozdz, 1968
	vole	common	M	0-15		0.0218	0.0025	Drozdz, 1968
Other	kestrel	Eurasian	M	1	~1200	0.179	0.01	Campbell and Koplin, 1986
	owl	screech	M	1	~300	0.169	0.0086	Campbell and Koplin, 1986
	turkey	Amerine, Nichola	M	40,40	294,329	13.4	0.372	Parker et al., 1972

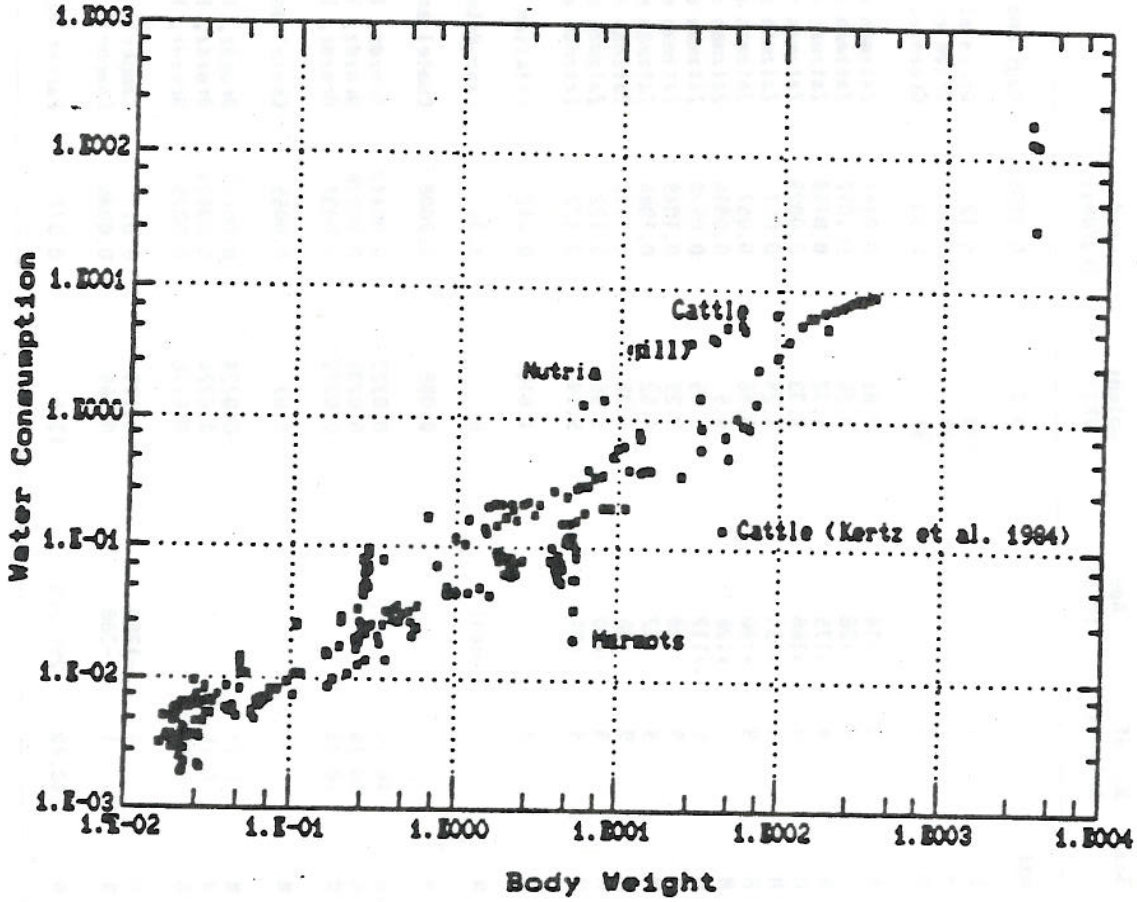


FIGURE 6-1

Plot of Food Consumption (kg/day) vs.
Body Weight (kg) for All Species

(See Table 6-1 for points and references)

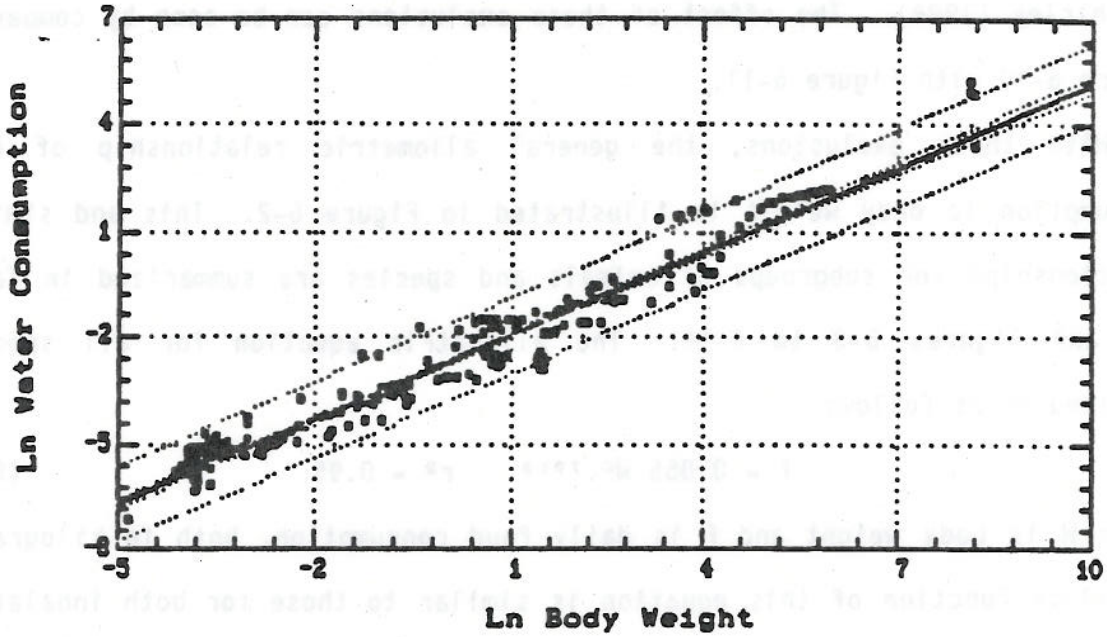
study, or in cattle from other studies. The Nutria (Lane-Peter et al., 1967) and one dog studied by Cowgill (1928) also are eliminated from subsequent statistical analyses as atypical. Although not apparent in Figure 6-1, the food consumption values for hamsters, reported by Arrington (1968) and Templeton (1968), vary markedly from other reports. The only other data excluded from the analyses are data on pregnant and lactating rats reported by Shirley (1984). The effect of these exclusions can be seen by comparing Figure 6-10 with Figure 6-11.

With these exclusions, the general allometric relationship of food consumption to body weight is illustrated in Figure 6-2. This and similar relationships for subgroups of animals and species are summarized in Table 6-2 and Figures 6-3 to 6-14. The allometric equation for all species combined is as follows:

$$F = 0.065\ W^{0.7919} \qquad r^2 = 0.95 \qquad (6\text{-}1)$$

where W is body weight and F is daily food consumption, both in kilograms. The slope function of this equation is similar to those for both inhalation rates (0.7579) (see Eq. 4-1) and drinking rates (0.7872) (see Eq. 5-1). This similarity is most likely related to the slope function for metabolic rate estimated at 0.76 (Benedict, 1938).

The negative correlations for both dogs and cats are probably artifacts of different diets. This is clearly the case for cats for which two primary studies, Waterhouse and Carver (1966) and Taton et al. (1984), are available. In the study by Taton et al. (1984), cats received a dry diet, and in the study by Waterhouse and Carver (1966) cats received a canned, moist diet. The cats in the study by Taton et al. (1984) were larger but consumed substantially less food than the cats in the study by Waterhouse and Carver (1966), which resulted in a negative slope (see Figure 4-12). In each



B0: -2.736 SE: 0.033886 T: -80.742
B1: 0.7919 SE: 0.011209 T: 70.65
CORR: 0.97512 MSE: 0.29743 DF: 258

FIGURE 6-2

Allometric Relationship of Food Consumption (kg/day) to Body Weight (kg) for All Species, Except Marmots

TABLE 6-2

Species and Group Specific Allometric Relationships for Food Consumption in kg/day (F) to Body Weight in kg (W)

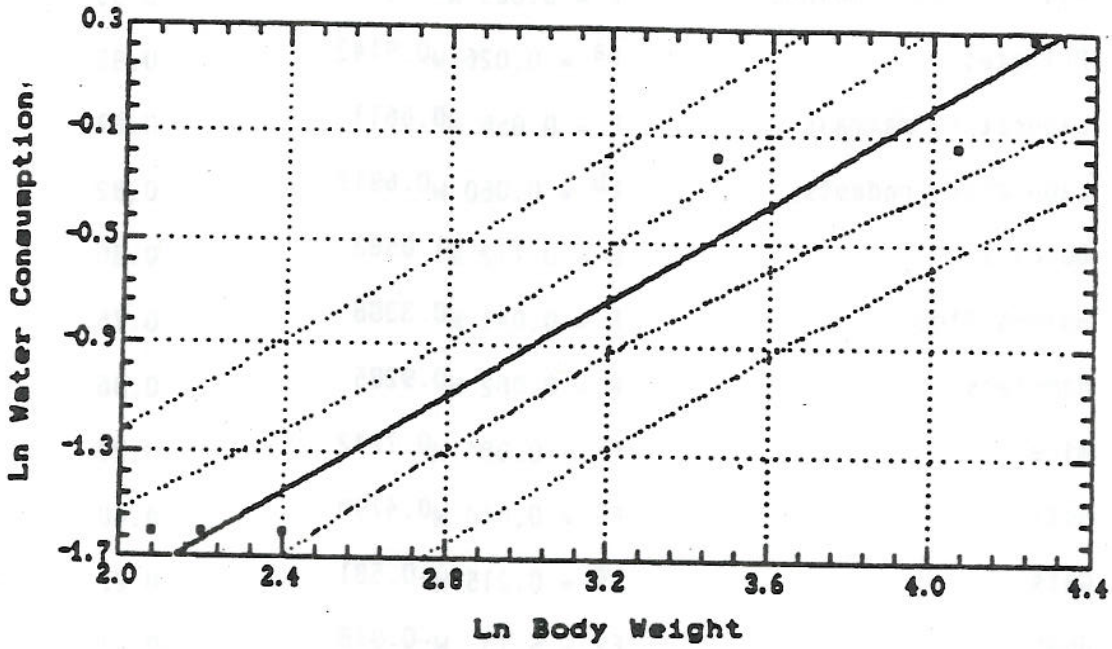
Animal Group	Allometric Equation	r^2	Figure
All species combined	$F = 0.065\ W^{0.7919}$	0.95	6-2
Primates	$F^a = 0.026\ W^{0.9142}$	0.95	6-3
Laboratory mammals	$F = 0.056\ W^{0.6611}$	0.87	6-4
Laboratory rodents	$F^b = 0.060\ W^{0.6917}$	0.82	6-5
Gerbils	$F = 0.112\ W^{1.0583}$	0.80	6-6
Guinea Pigs	$F = 0.041\ W^{0.3308}$	0.75	6-7
Hamsters	$F = 0.082\ W^{0.9285}$	0.96	6-8
Mice	$F^c = 0.064\ W^{0.7242}$	0.27	6-9
Rats	$F^c = 0.040\ W^{0.4790}$	0.40	6-11
Cats	$F^c = 0.215\ W^{-0.581}$	-0.22	6-12
Dogs	$F^c = 5.13\ W^{-0.918}$	-0.81	NA
Rabbits	$F = 0.041\ W^{0.7898}$	0.73	6-13
Chickens	$F = 0.075\ W^{0.8449}$	0.97	6-14

[a]Not recommended for calculating values. Use equation for all species combined.

[b]Not recommended for calculating values. Included for comparison only.

[c]Not recommended for calculating values. Use equation for laboratory mammals.

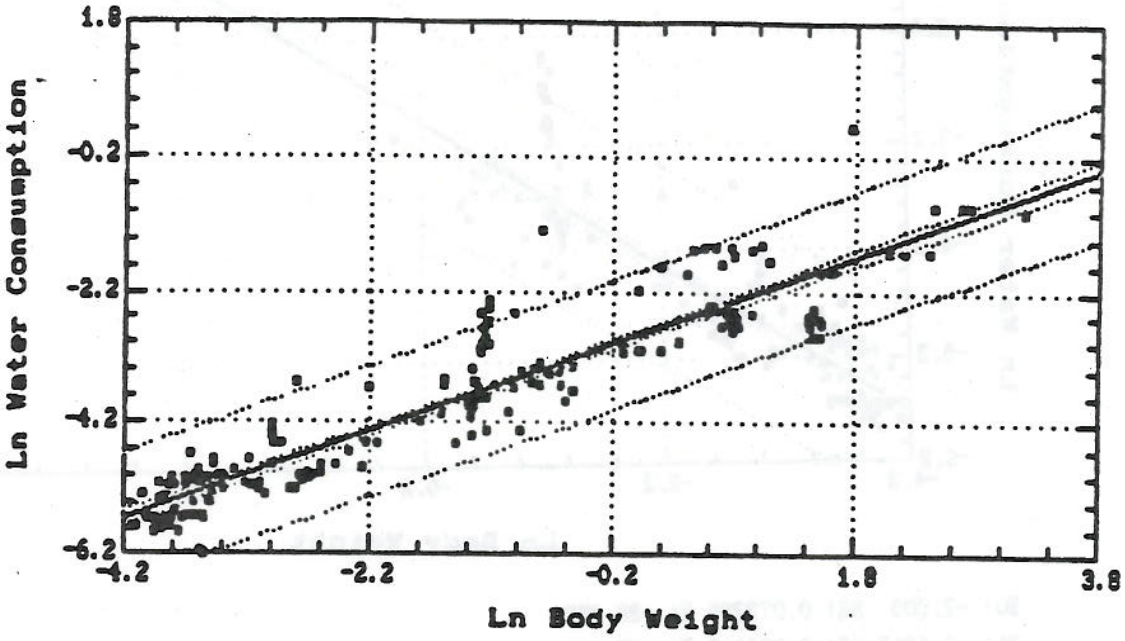
NA = Not applicable



B0: -3.6488 SE: 0.27537 T: -13.251
B1: 0.91415 SE: 0.088875 T: 10.286
CORR: 0.97718 MSE: 0.040392 DF: 5

FIGURE 6-3

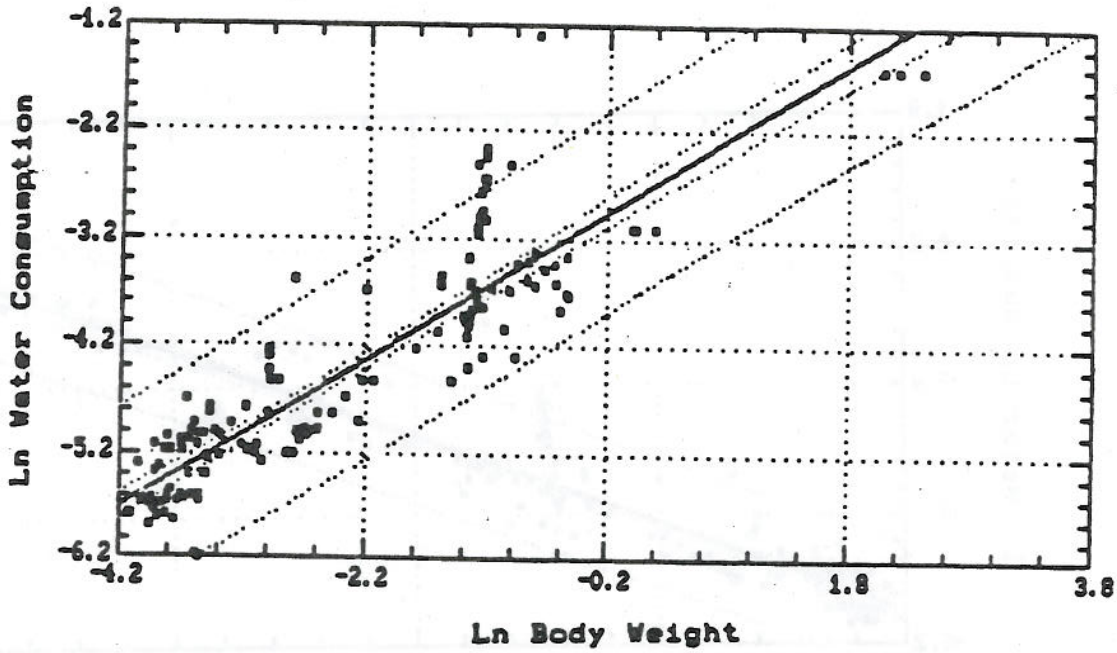
Allometric Relationship of Food Consumption (kg/day) to Body Weight (kg) for Primates



B0: -2.8899 SE: 0.039751 T: -72.699
B1: 0.66106 SE: 0.016814 T: 39.315
CORR: 0.9351 MSE: 0.25136 DF: 222

FIGURE 6-4

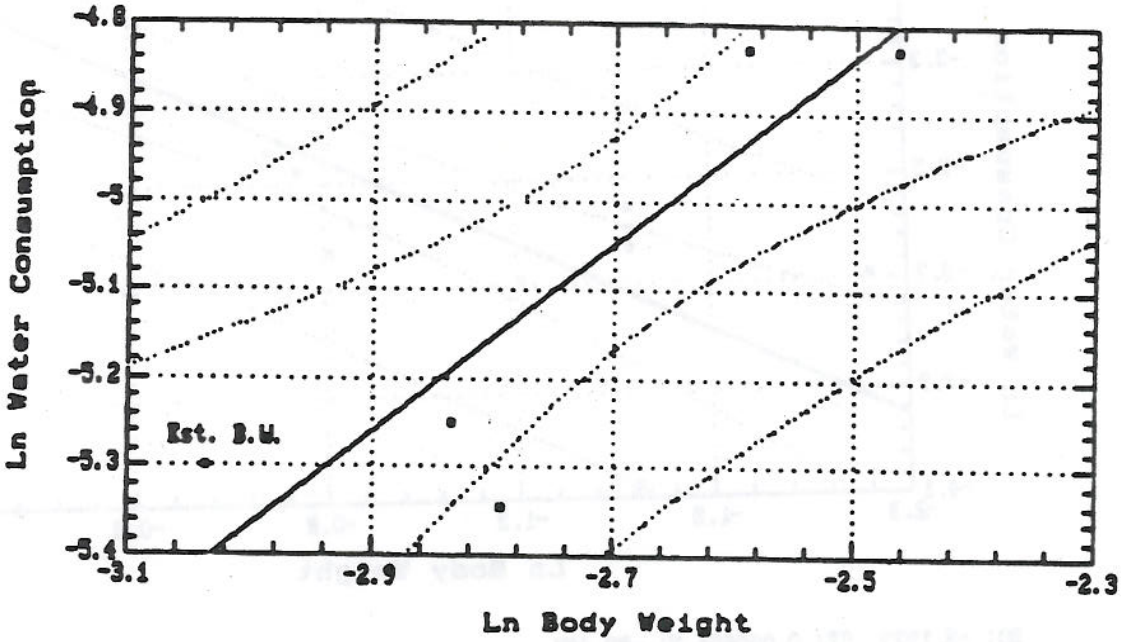
Allometric Relationship of Food Consumption (kg/day) to Body Weight (kg) for Laboratory Mammals (Gerbils, Guinea Pigs, Hamsters, Mice, Rats, Cats, Dogs and Rabbits).



B0: -2.809 SE: 0.072298 T: -38.853
B1: 0.6917 SE: 0.026617 T: 25.987
CORR: 0.90293 MSE: 0.21881 DF: 153

FIGURE 6-5

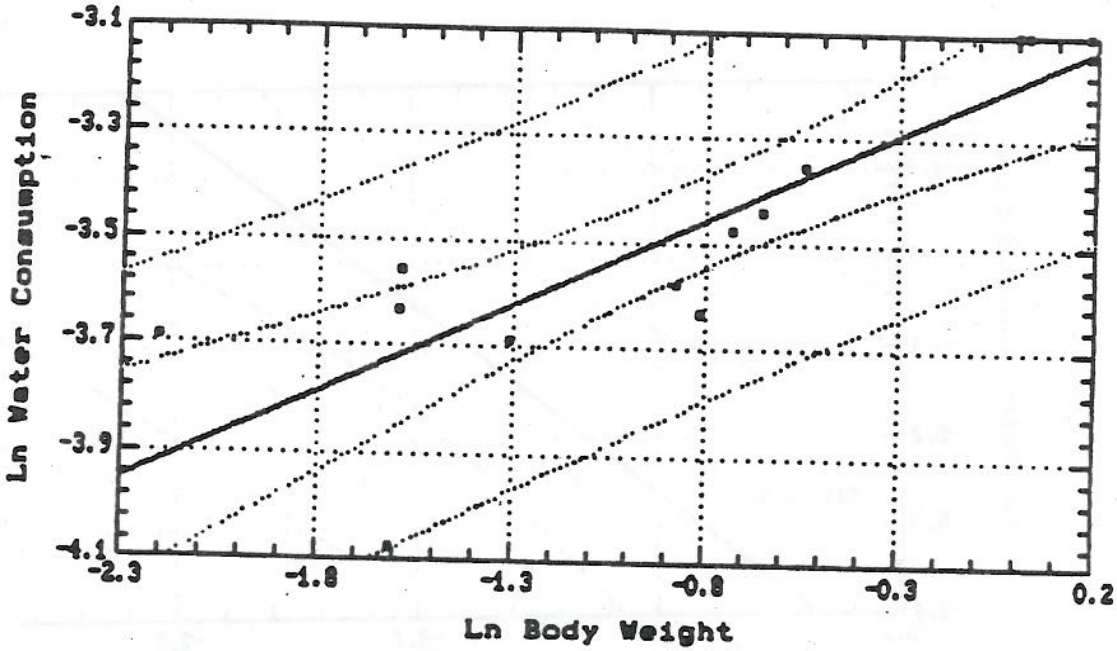
Allometric Relationship of Food Consumption (kg/day) to Body Weight (kg) for Laboratory Rodents (Gerbils, Guinea Pigs, Hamsters, Mice and Rats)



B0: -2.1909 SE: 0.63865 T: -3.4305
B1: 1.0583 SE: 0.23747 T: 4.4566
CORR: 0.8938 MSE: 0.015361 DF: 5

FIGURE 6-6

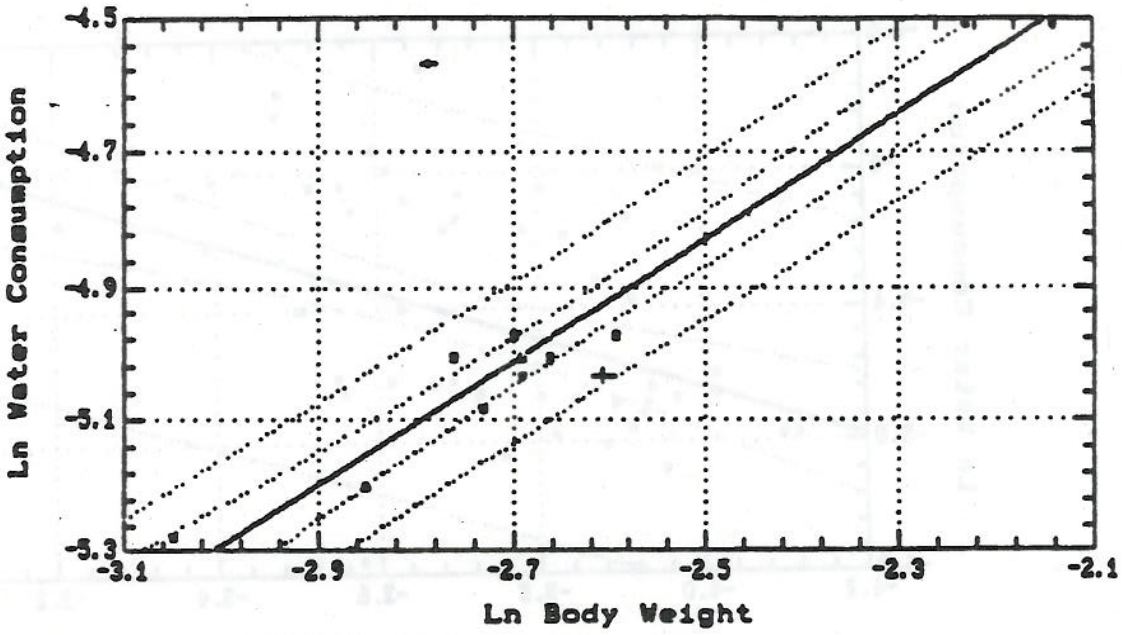
Allometric Relationship of Food Consumption (kg/day) to Body Weight (kg) for Gerbils



B0: -3.1929 SE: 0.060604 T: -52.685
B1: 0.33077 SE: 0.054986 T: 6.0155
CORR: 0.86658 MSE: 0.02263 DF: 12

FIGURE 6-7

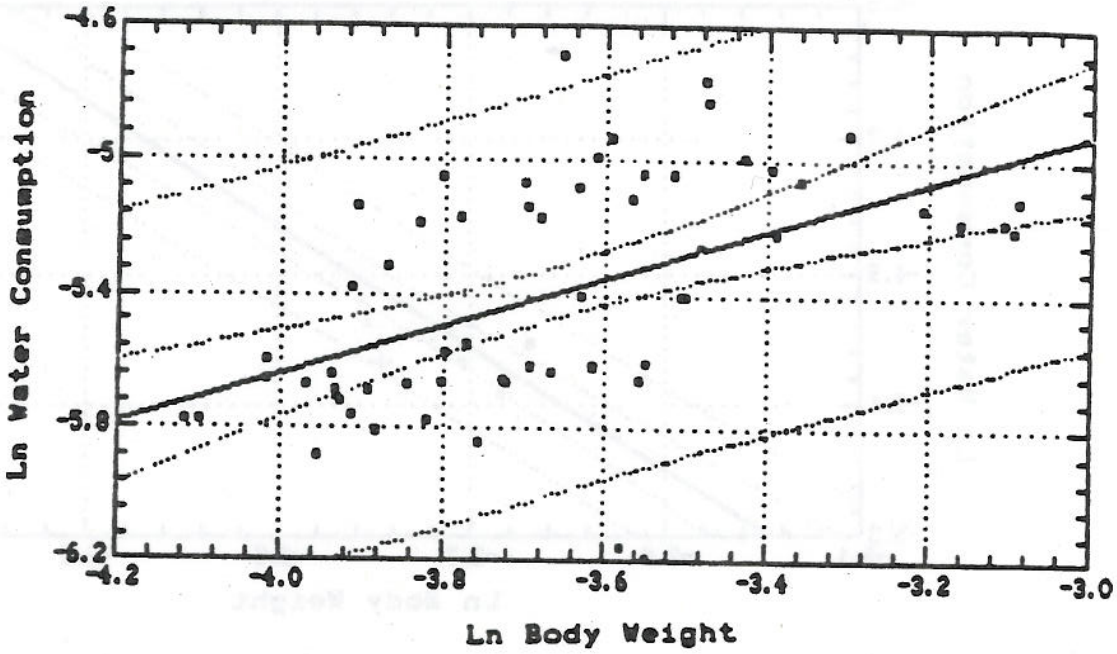
Allometric Relationship of Food Consumption (kg/day) to Body Weight (kg) for Guinea Pigs



B0: -2.5069 SE: 0.16645 T: -15.061
B1: 0.9285 SE: 0.062665 T: 14.817
CORR: 0.98011 MSE: 2.5965E-3 DF: 9

FIGURE 6-8

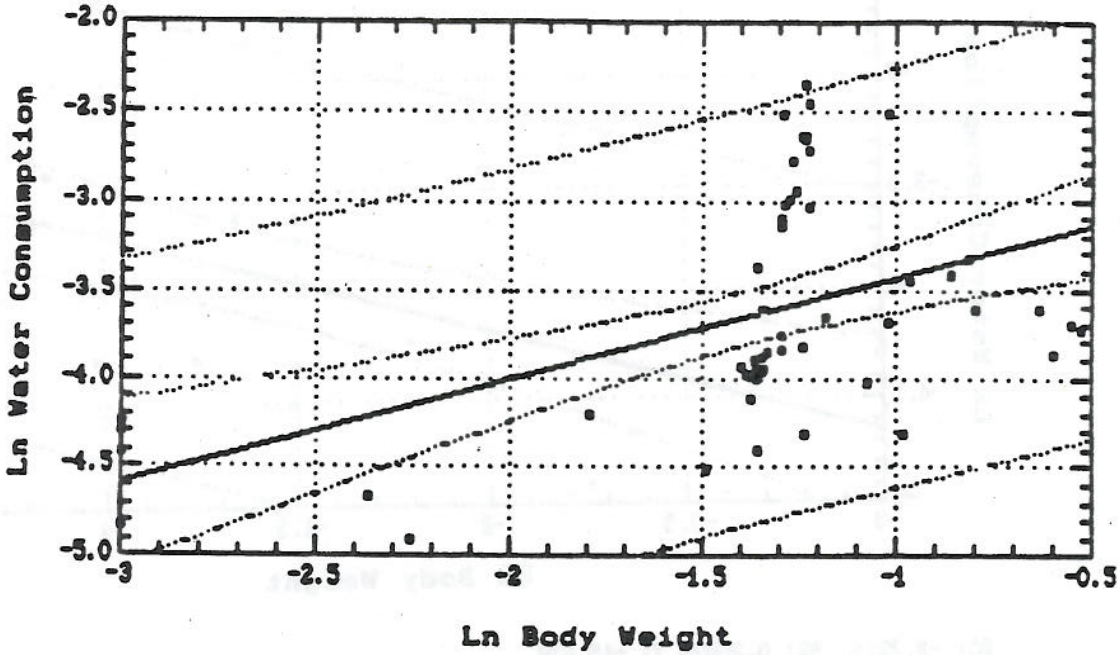
Allometric Relationship of Food Consumption (kg/day) to Body Weight (kg) for Hamsters



B0: -2.7418 SE: 0.56827 T: -4.8249
B1: 0.72423 SE: 0.15466 T: 4.6828
CORR: 0.52379 MSE: 0.089148 DF: 58

FIGURE 6-9

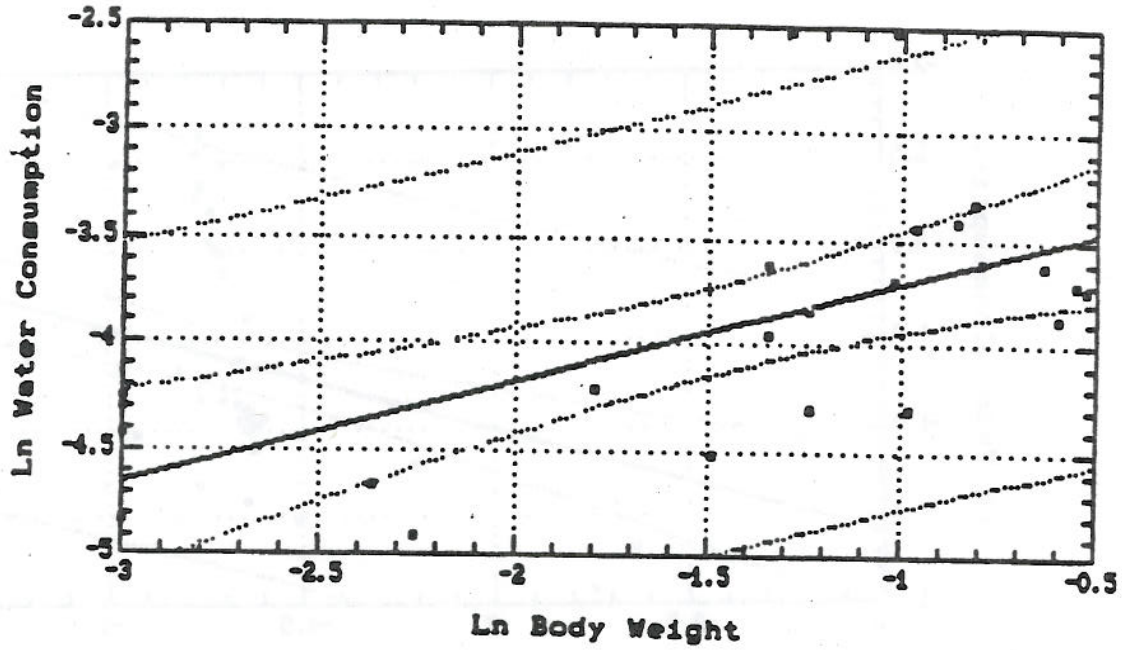
Allometric Relationship of Food Consumption (kg/day) to Body Weight (kg) for Mice



B0: -2.8561 SE: 0.20583 T: -13.876
B1: 0.57843 SE: 0.13754 T: 4.2056
CORR: 0.50022 MSE: 0.33354 DF: 53

FIGURE 6-10

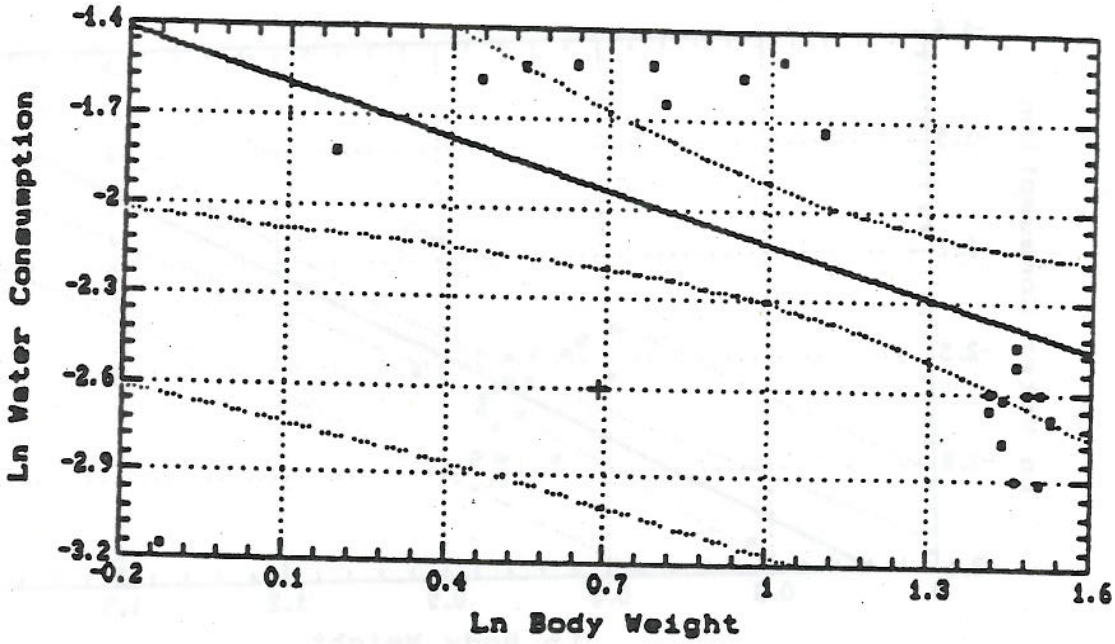
Allometric Relationship of Food Consumption (kg/day) to Body Weight (kg) for Rats, Including Pregnant and Lactating Animals



B0: -3.2218 SE: 0.20874 T: -15.434
B1: 0.47897 SE: 0.1223 T: 3.9162
CORR: 0.63249 MSE: 0.25313 DF: 23

FIGURE 6-11

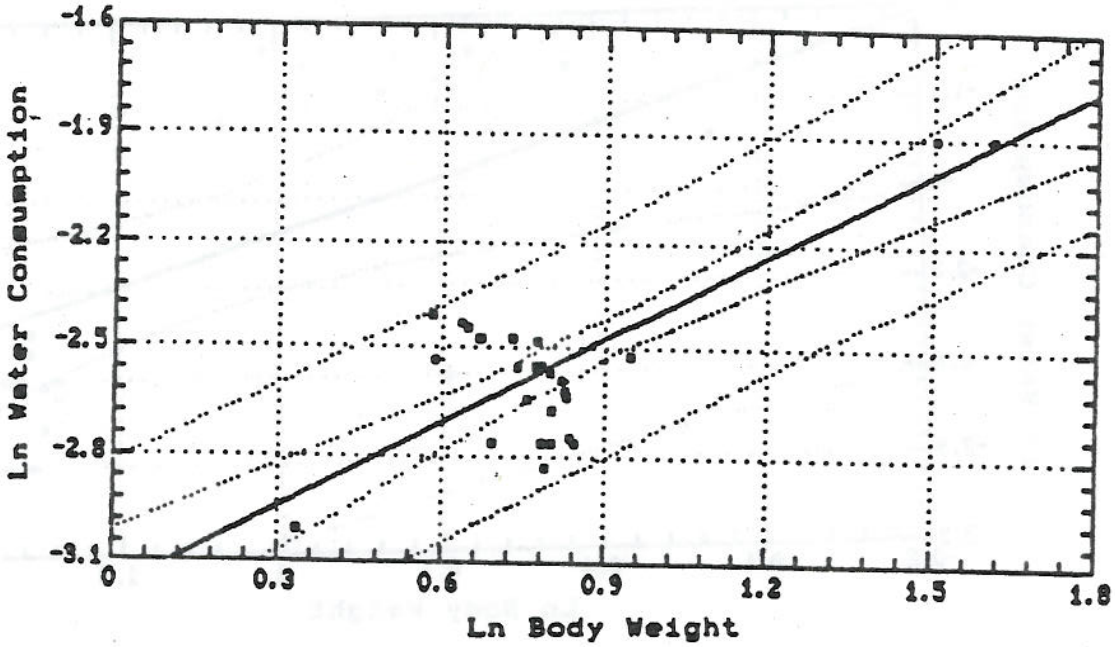
Allometric Relationship of Food Consumption (kg/day) to Body Weight (kg) for Rats, Excluding Pregnant and Lactating Animals



B0: -1.5356 SE: 0.25803 T: -5.9514
B1: -0.58062 SE: 0.21704 T: -2.6751
CORR: -0.46458 MSE: 0.25019 DF: 26

FIGURE 6-12

Allometric Relationship of Food Consumption (kg/day) to Body Weight (kg) for Cats



B0: -3.1835 SE: 0.083168 T: -38.278
B1: 0.78978 SE: 0.089449 T: 8.8294
CORR: 0.85374 MSE: 0.024701 DF: 29

FIGURE 6-13

Allometric Relationship of Food Consumption (kg/day) to Body Weight (kg) for Rabbits