

BOVINE (CATTLE – BEEF & DAIRY) - SERUM

BOVINE - SERUM - GROWING CALVES + ADULTS	Units	Normal
Calcium (tCa) – ionized calcium available from clinical pathology	ppm	90-120
Magnesium [#] (tMg) ionized Mg available from clinical pathology	ppm	18-30
Manganese [#]	ppm	0.002-0.010
Manganese whole blood	ppm	0.07-0.2
Iron ^{#@}	ppm	0.8-2.5
Cobalt [#]	ppb	0.17-2
Copper ^{#%}	ppm	0.6-1.1
Zinc ^{#@}	ppm	0.8-1.9
Selenium [#]	ppm	0.065-0.14
Selenium whole blood	ppm	0.12-0.3
Molybdenum	ppm	0.002-0.035
Lead whole blood	ppm	<0.01
Arsenic whole blood	ppb	<30
Vitamin A [#]	ppm	0.30-0.80
Vitamin E	ppm	3-10
Vitamin D calcifediol (25-OH-D ₃)	ppb	20-60 (up to 80) dependent on pregnancy/lactation
<ul style="list-style-type: none"> • ppm = mg / L = mcg/mL = 1000 ppb ppb = mcg/L • Conversion from dry weight to wet weight: multiply dry weight concentration by 0.28 to get approximate wet weight concentration) • Age definitions: growing calves = >3-4 months of age; adults (including yearlings) = ≥1 year old • Sources: Puls, R. Mineral Levels in Animal Health: Diagnostic Data. 2nd Edition. 1994 Corbett 2023 Vet Clin North Am Food Anim Pract Herdt and Hoff 2011 Vet Clin North Am Food Anim Pract Buchweitz, Sheffler, and Puschner 2023 Vet Clin North Am Food Anim Pract • Superscript legend: # = affected by hemolysis; @ = negative acute phase response; % = positive acute phase response 		

BOVINE - SERUM – NEONATAL	Units	Normal
Manganese [#]	ppm	0.001-0.004
Iron ^{#@}	ppm	0.25-1.7
Cobalt [#]	ppb	0.18-2.3
Copper ^{#%}	ppm	0.3-1.0
Zinc ^{#@}	ppm	0.6-1.75
Selenium [#]	ppm	0.02-0.07
Selenium whole blood	ppm	0.1-0.25
Molybdenum	ppm	0.001-0.015
Vitamin A [#] age required	ppm	0.2-0.33 age dependent
Vitamin E age required	ppm	0.08-0.1 age dependent
<ul style="list-style-type: none"> • ppm = mg/L = mcg/mL = 1000 ppb ppb = mcg/L • Neonatal: <30 days of age • Sources: Puls, R. Mineral Levels in Animal Health: Diagnostic Data. 2nd Edition. 1994 Corbett 2023 Vet Clin North Am Food Anim Pract Herdt and Hoff 2011 Vet Clin North Am Food Anim Pract Buchweitz, Sheffler, and Puschner 2023 Vet Clin North Am Food Anim Pract • Superscript legend: # = affected by hemolysis; % = positive acute phase response (ceruloplasmin); @ = negative acute phase response (transferrin, albumin) 		

BOVINE (CATTLE – BEEF & DAIRY) - LIVER

BOVINE - LIVER – WET WEIGHT –GROWING CALVES + ADULT	Units	Normal
Calcium	ppm	30-200
Phosphorus	ppm	2000-4500
Chromium	ppm	0.04-3.8
Potassium	ppm	1400-4000
Magnesium	ppm	100-250
Manganese [§]	ppm	2-6
Iron ^{%§}	ppm	45-300
Cobalt	ppb	20-200
Copper [§]	ppm	25-100
Zinc ^{%§}	ppm	25-100
Selenium [§]	ppm	0.25-0.50
Molybdenum	ppm	0.1-1.4
Lead [§]	ppm	<0.1
Arsenic [§]	ppm	<0.1
Vitamin A	ppm	85-200
Vitamin E	ppm	4-8.5
<ul style="list-style-type: none"> • Conversion from dry weight to wet weight: multiply dry weight concentration by 0.28 to get approximate wet weight concentration) • Age definitions: growing calves = >3-4 months of age; adults (including yearlings) = ≥1 year old • Sources: Puls, R. Mineral Levels in Animal Health: Diagnostic Data. 2nd Edition. 1994 Corbett 2023 Vet Clin North Am Food Anim Pract Herdt and Hoff 2011 Vet Clin North Am Food Anim Pract Buchweitz, Sheffler, and Puschner 2023 Vet Clin North Am Food Anim Pract • Superscript legend: % = positive acute phase response; § = ideal sample for assessment (caveat: zinc has no well-defined easily sampled storage pool) 		

BOVINE - LIVER – WET WEIGHT – FETAL/ NEONATAL	Units	Normal
Calcium	ppm	30-200
Phosphorus	ppm	2000-4500
Chromium	ppm	0.04-3.8
Potassium	ppm	1400-4000
Magnesium	ppm	100-250
Manganese lower than maternal	ppm	0.9-4.5
Iron higher than maternal	ppm	55-550
Cobalt	ppb	10-100
Copper higher than maternal	ppm	65-150
Zinc higher than maternal	ppm	35-125
Selenium higher than maternal	ppm	0.35-1.3
Molybdenum	ppm	0.1-1.4
Vitamin A	ppm	Minimal placental transfer during gestation; highly dependent on colostrum intake and age
Vitamin E	ppm	
Sources: Puls, R. Mineral Levels in Animal Health: Diagnostic Data. 2nd Edition. 1994 Corbett 2023 Vet Clin North Am Food Anim Pract Herdt and Hoff 2011 Vet Clin North Am Food Anim Pract Buchweitz, Sheffler, and Puschner 2023 Vet Clin North Am Food Anim Pract		

OVINE (SHEEP) - SERUM

OVINE - SERUM - ADULT + GROWING LAMBS	Units	Normal
Magnesium ^{# tMg}	ppm	22-28
Manganese [#]	ppm	0.001-0.006
Manganese <i>whole blood</i>	ppm	0.02-0.025
Iron ^{#@}	ppm	0.9-2.7
Cobalt [#]	ppb	0.18-2.0
Copper ^{#%}	ppm	0.75-1.7
Zinc ^{#@}	ppm	0.55-1.2
Selenium [#]	ppm	0.06-0.20
Selenium <i>whole blood</i>	ppm	0.12-0.35
Molybdenum	ppm	0.001-0.050
Vitamin A [#]	ppm	0.3-0.6
Vitamin E	ppm	1.5-3.0
<ul style="list-style-type: none"> • ppm = mg/L / = mcg/mL = 1000 ppb ppb = mcg/L • Sources: Puls, R. Mineral Levels in Animal Health: Diagnostic Data. 2nd Edition. 1994 Corbett 2023 Vet Clin North Am Food Anim Pract Herdt and Hoff 2011 Vet Clin North Am Food Anim Pract Buchweitz, Sheffler, and Puschner 2023 Vet Clin North Am Food Anim Pract Van Saun 2023 Vet Clin North Am Food Anim Pract • Superscript legend: # = affected by hemolysis; % = positive acute phase response; @ = negative acute phase response • Plasma Cu >1.35 mg/L indicates poisoning 		

OVINE - LIVER

OVINE - LIVER – WET WEIGHT	Units	Normal	Fetal/neonatal normal (where available)
Magnesium	ppm	118-200	?
Manganese	ppm	1.2-5.9	1-2
Iron	ppm	70-300	400-600
Cobalt	ppb	20-120	?
Copper	ppm	25-100	16-54
Zinc	ppm	22-85	40-80
Selenium	ppm	0.25-1.5	0.25-1.5
Molybdenum	ppm	0.08-1.3	?
Vitamin A	ppm	140-280	Dependent on age and colostrum intake
Vitamin E	ppm	3-50	
Sources: Puls, R. Mineral Levels in Animal Health: Diagnostic Data. 2 nd Edition. 1994 Corbett 2023 Vet Clin North Am Food Anim Pract Herdt and Hoff 2011 Vet Clin North Am Food Anim Pract Buchweitz, Sheffler, and Puschner 2023 Vet Clin North Am Food Anim Pract Van Saun 2023 Vet Clin North Am Food Anim Pract			

EQUINE (HORSES, PONIES, DONKEYS) - SERUM

EQUINE - SERUM - ADULTS	Units	Normal
Magnesium ^{# tMg}	ppm	18-35
Manganese [#]	ppm	0.0005-0.002
Iron ^{#@}	ppm	0.84-2.6
Cobalt [#]	ppb	>0.25
Copper ^{#%}	ppm	0.5-2.0
Zinc ^{#@}	ppm	0.6-1.7
Selenium [#]	ppm	0.14-0.250
Selenium <i>whole blood</i>	ppm	0.17-0.3
Molybdenum	ppm	0.0012-0.030
Vitamin A [#]	ppm	0.2-0.35
Vitamin E	ppm	2-10
<ul style="list-style-type: none"> • ppm = mg/L = mcg/mL = 1000 ppb ppb = mcg/L • Source: Puls, R. Mineral Levels in Animal Health: Diagnostic Data. 2nd Edition. 1994 • Superscript legend: # = affected by hemolysis; % = positive acute phase response; @ = negative acute phase response 		