

CHAPTER 6**CONCLUSIONS**

The purpose of the present study was to investigate visual body condition scoring (BCS) and percentage bone marrow fat (%BMF) for use on the African buffalo and to correlate these with proximate body fat content, to establish which gives the best estimate of body condition / composition. BCS and %BMF were poor predictors of proximate body composition, although %BMF was more accurate in older animals. It is difficult to obtain a measure of the animals' condition based on a single measurement, as there are numerous factors (nutritional, genetic, pathological, climatic and reproductive), which influence body condition.

The effects of region as well as gender and age, on the carcass composition of African buffalo were also investigated. The BCS did not differ between regions in the KNP, but differences in %BMF were observed ($P=0.0001$). Proximate body composition was influenced by sex, age and ecological region. Fat content was higher ($P<0.05$) and head weights lower ($P<0.05$) in females compared to males. Fat concentration increased with age from 11% in juvenile buffalo to 14% in adult buffalo. Fat content was lower (9.9%) in buffalo from the southern region (high BTB region) compared to those in the central region (12.5%) and northern region (11.5%). Carcass mass was lower ($P<0.05$) in the central region compared to the rest of the KNP. A significant correlation was observed between BTB and body condition of African buffalo in the southern region of the KNP. In this region, BTB was associated with a decrease in the overall body condition of buffalo.

Higher pH values observed in carcasses from BTB positive buffalo were attributed to lower glycogen levels in their carcasses. Regional and age effects on carcass pH were also detected.

From the results obtained for the minerals analysed, it appears that most areas in the KNP have adequate mineral levels when the trace mineral tissue levels of cattle (Puls, 1994) are used as reference. The tissue mineral levels for

Se and Cu indicate that there are significant differences between the different regions of the KNP, with a marginal deficiency in their levels in the southern region. A significant difference in Se status between different sexes was also observed in the KNP, particularly in the northern region. In the central and southern regions of the KNP there were significant differences in the Cu-concentrations between BTB positive and BTB negative buffalo.

References

- Abbas, A.K., Lichtman, A.H. & Prober, J.S. 1991. Cellular and Molecular Immunology. W.B. Saunders Co., Philadelphia, PA.
- Allen, P. 1990. New approach to measuring body composition in live meat animals. In Reducing Fat in Meat Animals, ed. J. D. Wood and A. V. Fisher. Elsevier Applied Science, Barking, England, 201-254.
- Allen, P. & Vagen, O. 1984. X-ray tomography of pigs - some preliminary results. In. *In Vivo* Measurement of Body Composition in Meat animals, ed. D. Lister. Elsevier Applied Science Publishers, London, 55-66.
- Alliston, J.C., Barker, J. D., Kempster, A.J. & Arnall, D. 1981. The use of two ultrasonic machines (Danscanner and scannogram) for the prediction of body composition in crossbred lambs. *Animal Production*. 32, 375 (Abstract).
- Anderson, J.L. 1979. Reproductive seasonality of the nyala *Tragelaphus angasi*; The interaction of light, vegetation phenology, feeding style and reproductivity. *Mammal Review*. 9, 33 - 46.
- Armstrong, F.B. 1989. Biochemistry 3rd edition. Oxford University Press, Inc. 200 Madison Avenue, New York, New York 10016.
- Arthington, J.D., Corah, L.R. & Blecha, F. 1995. Effect of molybdenum-induced copper deficiency on in vivo and in vitro measures of neutrophil chemotaxis both prior to and following an inflammatory stressor. *Journal of Animal Science*. 73(1), 266 (Abstr.).
- Arthington, J.D., Corah, L.R. & Blecha, F. 1996. The effect of molybdenum-induced copper deficiency on acute phase protein concentrations, superoxide dismutase activity, leukocyte numbers and lymphocyte proliferation in beef

heifers inoculated with bovine herpesvirus-1. *Journal of Animal Science*. 74, 211-217.

Arthur, J.R. & Becket, G.J. 1994b. New metabolic roles for selenium. *Proceedings of the Nutrition Society*. 53, 615-623.

Arthur, J.R. & Boyne, R. 1985. Superoxide dismutase and glutathione peroxidase activities in neutrophils from selenium deficient and copper deficient cattle. *Life Sciences*. 36, 1569-1575.

Arthur, J.R., Price, J. & Mills, C.F. 1979. Observations on the selenium status of cattle in the north-east Scotland. 104, 304-341.

Aziz, C.S. & Klesius, P.H. 1985. The effect of selenium deficiency in goats on lymphocyte production of leukocyte migration inhibitory factor. *Veterinary Immunology and Immuno-pathology*. 10, 381-390.

Aziz, C.S. & Klesius, P.H. 1986. Depressed neutrophil chemotactic stimuli in supernatants of ionophore-treated polymorphonuclear leucocytes from selenium-deficient goats. *American Journal of Veterinary Research*. 47, 148-151.

Aziz, C.S., Frandsen, P.H. & Klesius, P.H. 1984. Effect of selenium on polymorphonuclear leukocyte function in goats. *American Journal of Veterinary Research*. 45, 1715-1718.

Baalsrud, K.J. & Øvernes, G. 1986. Influence of vitamin E and selenium supplement on antibody production in horses. *Equine Veterinary Journal*. 18, 472-474.

Bandy, P.J., Cowan, I. McT., Kitts, W.D., & Wood, A.J. 1956. A method of the assessment of the nutritional status of wild ungulates. *Canadian Journal of Zoology*. 34, 48 – 52.

Bandy, P.J., Kitts, W.D., Wood, A.J., & Cowan, I. McT. 1957. The effect of age and the plane of nutrition on the blood chemistry of the Columbian black-tailed deer (*Odocoileus hemionus columbianus*) blood glucose, non-protein nitrogen, total plasma protein, plasma albumin, globulin, and fibrinogen. *Canadian Journal of Zoology*. 35, 283 – 289.

Barlow, N. 1994. Bovine tuberculosis in New Zealand: epidemiology and models. *Trends in Microbiology*. 2, 119-124.

Bear, G.D. 1971. Seasonal trends in fat levels of pronghorns, *Antilocaprea americana*, in *Colorado Journal of Mammals*. 52, 583 – 589.

Bell, L.T. & Hurley, L.S. 1974. Histochemical enzyme changes in epidermis of manganese-deficient foetal mice. *Proceedings of the Society for Experimental Biology and Medicine*. 145, 1321-1324.

Bendall, J.R. 1973. Postmortem changes in muscle. The structure and function of muscle, Bourne, G.H.(ed) Vol. 2, P. 2, 244-309. Academic Press, New York.

Bendich, A. 1990. Antioxidant nutrients and immune functions. *Advances in experimental medicine and biology*. (N. Back, *et al.*, eds). Plenum Press. Volume 262.

Bengis, R.G. 1999. Tuberculosis in free-ranging mammals. *Zoo and wild animal medicine*. 101-114 (Fowler, M.E. & Miller, R.E., eds). W.B. Saunders Company, Philadelphia, Pennsylvania.

Bengis, R.G. & Erasmus, J.M. 1988. Wildlife diseases in South Africa: a review. *Revue Scientifique et Technique (International Office of Epizootics)*. 7, 807-821.

Bengis, R.G. & Keet, D.F. 1998. Bovine tuberculosis in free-ranging kudu (*Tragelaphus strepsiceros*) in the Greater Kruger National Park complex. Proc. ARC-Onderstepoort OIE International Congress with WHO-Co-sponsorship on anthrax, brucellosis, CBPP, clostridial and mycobacterial diseases, 9-15 August, Pretoria. Sigma Press, Pretoria, 418-421.

Bengis, R.G., Kriek, N.P.J., Keet, K.F., Raath, J.P., De Vos, V. & Huchzermeyer, H. 1996. An outbreak of bovine tuberculosis in a free-living African buffalo (*Syncerus caffer* Sparrman) population in the Kruger National Park: a preliminary report. *Onderstepoort Journal of Veterinary Research*. 63, 15-18.

Boyazoglu, P.A. 1997. Animal nutrition: concepts and applications. J.L. van Schaik Publishers, Hatfield, Pretoria.

Boyne, R., & Arthur, J.R. 1979. Alterations of neutrophil function in selenium-deficient cattle. *Journal of Comparative Pathology*. 89, 151-158.

Boyne, R., & Arthur, J.R. 1981. Effect of selenium and copper deficiency on neutrophil function in cattle. *Journal of Comparative Pathology*. 91, 271-276.

Boyne, R., & Arthur, J.R. 1986. Effects of molybdenum- or iron-induced copper deficiency on the viability and function of neutrophils from cattle. *Research in Veterinary Science*. 4, 417-419.

Bracco, E. F., Yang, M.U., Segal, K., Hashim, S. A. & Van Itallie, T.B. 1983. A new method for estimation of body composition in the live rat. *Proceedings of the Society for Experimental Biology*. 174, 143-146.

- Brazle, F.K., & Stokka, G.L. 1994. The effect of copper sulfate and zinc oxide in a drench on the gain and health of newly arrived calves. *Journal of Animal Science*. 72 (Suppl. 2): 42 (Abstr.).
- Brooks, P.M. 1978. Relationship between body condition and age, growth, reproduction and social status in impala, and its application to management. *South African Journal of Wildlife Research*. 8, 151 – 157.
- Brooks, P.M., Hanks, J. & Ludbrook, J.V. 1977. Bone marrow as an index of condition in African ungulates. *South African Journal of Wildlife Research*. 7, 61 – 66.
- Caron, A., Cross, P.C. & Du Toit, J.T. 2003. Ecological Implications of Bovine Tuberculosis in African Buffalo Herds. *Ecological Applications*. 13(5), 1338 – 1345.
- Casey, N.H. 1993. Carcass and meat quality. In *Livestock Production Systems: Principles and Practice*. Maree, C. and Casey, N.H. (Eds). Agri-Development foundation. Brooklyn.
- Cerone, S., Sansinanea, A. & Auza, N. 1995. Copper deficiency alters the immune response of bovine. *Nutrition Research*. 15, 1333-1341.
- Cheng, W.-H., Ho, Y.-S., Ross, D.A., Valentine, B.A. Combs, G.F. & Lei, X.G. 1997. Cellular glutathione peroxidase knockout mice express normal levels of selenium-dependent plasma and phospholipid hydroxide glutathione peroxidases in various tissues. *Journal of Nutrition*. 127, 1445-1450.
- Chirase, N.K., Hutcheson, D.P. & Thompson, G.B., 1991. Feed intake, rectal temperature, and serum mineral concentrations of feedlot cattle fed zinc oxide or

- zinc methionine and challenged with infectious bovine rhinotracheitis virus. *Journal of Animal Science*. 69, 4137-4145.
- Chu, F.F., Doroshov, J.H. & Esworhy, R.S. 1993. Expression characterisation and tissue distribution of a new cellular selenium dependent glutathione peroxidase GSHOx-G1. *Journal of Biological Chemistry*. 268, 2571-2576.
- Cosivi, O., Meslin, F., Daborn, C. & Grange, J. 1995. Epidemiology of *Mycobacterium bovis* infection in animals and humans, with particular reference to Africa. *Revue Scientifique et Technique*. 14, 733-746.
- Dauphine, T.C., 1975. Kidney weight fluctuations affecting the kidney fat index in caribou. *Journal of Wildlife Management*. 39, 379 – 386.
- De Vos, V., McCully, R.M. & Van Niekerk, C.A.W.J. 1977. Mycobacteriosis in the Kruger National Park. *Koedoe*. 20, 1-9.
- Domermuth, W. F., Veum, T.L., Alexander, M.A., Hedrick, H.B., Clark, J. & Eklund, D. 1976. Prediction of lean body composition of live market weight swine by indirect methods. *Journal of Animal Science*. 43, 966-976.
- Droke, E.A. & Loerch, S. C. 1989. Effects of parenteral selenium and vitamin E on performance, health and humoral immune response of steers new to the feedlot environment. *Journal of Animal Science*. 67, 1350-1359.
- Dunham, K.M. & Murray, M.G. 1982. The fat reserves of impala *Aepyceros melampus*. *African Journal of Ecology*. 20, 81 – 87.
- Egan, A.R. 1972. Reproductive responses to supplemental zinc and manganese in grazing Dorset Horn ewes. *Australian Journal of Experimental Agriculture and Animal Husbandry*. 12, 131-135.

- Ellis, T.M., Masters, H.G., Hustas, L., Sutherland, S.S. & Evans, R. 1990. The effect of selenium supplementation on antibody response to bacterial antigens in Merino sheep with a low selenium status. *Aust. Vet. J.* 67, 226-228.
- Eskew, M.L., Scholz, R.W., Reddy, C.C., Todhunter, D.A. & Zarkower, A. 1985. Effects of vitamin E and selenium deficiencies on rat immune function. *Immunology.* 54, 173-180.
- Eveleigh, C.F., Thwaites, C.J., Hassab, P.B., Paton, P.G., Smith, R.J. & Upton, W.H. 1985. A note on the ability of three portable ultrasonic probes to predict backfat thickness in cattle. *Animal Production.* 41, 247-248.
- Fahey, T.J., Schaefer, D.M., Kauffman, F.G., Epley, R.J., Gould, P.F., Romans, J.R., Smith, G.C. & Topel, D.G. 1977. A comparison of practical methods to estimate pork carcass composition. *Journal of Animal Science.* 44, 8 - 17.
- Finch, J.M. & Turner, R.J., 1986. Selenium supplementation in lambs: effects on antibody responses to a salmonella vaccine. *The Veterinary Record.* 119, 430-431.
- Finch, J.M. & Turner, R.J. 1989. Enhancement of ovine lymphocyte responses: a comparison of selenium and vitamin E supplementation. *Veterinary Immunology and Immuno-pathology.* 23, 245-256.
- Finch, J.M. & Turner, R.J. 1996. Effects of selenium and vitamin E on the immune responses of domestic animals. *Research in Veterinary Science.* 60, 97-106.

Fisher, A.V. 1990. New approaches to measuring fat in carcasses. in *Reducing Fat In Meat Animals*, ed. J. D. Wood and A. V. Fisher. Elsevier Applied Science, Barking, England, 255-343.

Fisher, G., & MacPherson, A. 1986. Co-deficiency in the pregnant ewe and lamb viability. Proceedings of the 6th International Conference on Production and Disease in Farm Animals, pp. 158-162.

Forrest, J.C. 1995. New techniques for estimation of carcass composition. in *Quality and Grading of Carcasses of Meat Animals.*, ed. S. D. M. Jones. CRC. Press, Inc., U. S. A. pp. 157-172.

Fortin, A. 1980. Fat thickness measured with three ultrasonic instruments on live ram lambs as predictions of cutability. *Canadian Journal of Animal Science.* 60, 857-867.

Fortin, A., Jones, S.D.M. & Howorth, C.R. 1984. Pork carcass grading : A comparison of the New Zealand Hennessy Grading Probe and the Danish Fat-O-Meter. *Meat Science.* 10, 131-144.

Franzmann, A.W. & Leresche, R.E. 1978. Alaskan moose blood studies with emphasis on condition evaluation. *Journal of Wildlife Management.* 42, 334 – 351.

Fuller, M.F., Foster, M.A. & Hutchison, J.M.S. 1984. Nuclear magnetic resonance imaging of pigs. in *In Vivo Measurement of Body Composition in Meat Animals*, ed. D. Lister. Elsevier Applied Science Publishers, London, pp. 123-133.

Ferguson, E.G.W., Mitchell, G.B.B., & MacPherson, A. 1989. Cobalt deficiency and *Ostertagia circumcincta* infection in lambs. *Veterinary Record.* 124, 20.

- Ganther, H.E., Hafeman, D.G., Lawrence, R.A., Serfass, R.E. & Hoekstra, W.G. 1976. Selenium and glutathione peroxidase in health and disease: a review. Trace Elements in Human Health and Disease, Vol. 2. Prasad, A.S. (Ed). Academic Press, New York, pp. 165-234.
- Gelman, A.L., 1985. Some Studies with a Varian VGA-76 Hydride Generator for Selenium Determination. *Eur. J. Clin. Invest.* 15, 105-110.
- Gengelbach, G.P., Ward, J.D. & Spears, J.W. 1997. Effect of copper deficiency and copper deficiency coupled with high dietary iron or molybdenum and phagocytic function and response of calves to a respiratory disease challenge. *Journal of Animal Science*. 75, 1113-1118.
- Gertenbach, W.P.D., 1983. Landscapes of the Kruger National Park. *Koedoe* 26, 9-121.
- Golden, M.H. & Ramdath, D. 1987. Free radicals in the pathogenesis of kwashiorkor. *Proceedings of the Nutrition Society*. 46, 53-68.
- Grasso, P.J., Scholz, R.W., Erskine, R.J. & Eberhart, R.J. 1990. Phagocytosis, bactericidal activity, and oxidative metabolism of milk neutrophils from dairy cows fed selenium-supplemented and selenium-deficient diets. *American Journal of Veterinary Research*. 51, 269-274.
- Greer, K.R. 1968. A compression method indicates fat content of elk (Wapiti) femur marrows. *Journal of Wildlife Management*. 32, 747 – 751.
- Gregory, E.M. & Fridovich, I. 1974. Superoxide dismutases: properties, distribution, and functions. Trace Element Metabolism in Animals – 2. Hoekstra, W.G., Suttie, J.W., Ganther, H.E. and Mertz, W. (Eds). University Park Press, Baltimore, pp. 486-488.

Gresham, J.D., Holloway, J.W., Butts, Jr. W.t., & McCurley, J.R. 1986. Prediction of mature cow carcass composition from live animal measurements. *Journal of Animal Science*. 63, 1041.

Grobler, D.G. & Swan, G.E., 1999. Copper poisoning in the Kruger National Park: Field investigation in wild ruminants. *Onderstepoort Journal of Veterinary Research*. 66, 157.

Groeneveld, E., Kallweit, E., Hemming, M. & Pfau, A. 1984. Evaluation of body composition of live animals by X-ray nuclear magnetic resonance computed tomography. In *In Vivo Measurement of Body Composition in Meat Animals*, ed. D. Lister. Elsevier Applied Science Publishers, London, pp. 84-88.

Hanks, J., Cumming, D.H.M., Orpen, J.L., Parry, D.F. & Warren, H.B. 1976. Growth, condition and reproduction in the impala ram (*Aepyceros melampus*). *Journal of Zoology*. (Lond.). 179, 421 – 435.

Harris, D. 1945. Symptoms of malnutrition in deer. *Journal of Wildlife Management*. 9, 319 – 322.

Hayek, M.G., Mitchell, Jr. G.E., Harmon, R.J., Stahly, T.S., Cromwell, G.L. Tucker, R.E. & Barker, K.B. 1989. Porcine immunoglobulin transfer after prepartum treatment with selenium or vitamin E. *Journal of Animal Science*. 67, 1299-1306.

Heckman, M. 1971. Collaborative Study of Copper in Feeds by Atomic Absorption Spectrophotometry. *Journal of the Association of Official Analytical Chemists*. 54, 666 – 680.

- Herd, D.B. & Sprott, L.R. 1986. Body condition, nutrition and reproduction of beef cows. External Bulletin. 1526, Texas A&M Univ., College Station.
- Hill, H.A.O. 1981. Oxygen, oxidases, and the essential trace minerals. Philosophical Transactions of the Royal Society of London Series B Biological Sciences, 294. 119-128.
- Hirst, S.M. 1969. Predation as a regulating factor of wild ungulate populations in a Transvaal low veld nature reserve. Zoologica Africana. 4, 199 – 231.
- Houghton, P.L., Lemenager, R.P., Moss, G.E. & Hendrix, K.S. 1990. Prediction of postpartum beef cow body composition using weight to height ratio and visual body condition score. Journal of Animal Science. 68,1428 – 1437.
- Hughes, E. & Mall, R. 1958. Relation of the adrenal cortex to condition in deer. Californian Fish Game. 44, 191–196.
- Hurley, L.S. & Keen, C.L. 1987. Manganese. Trace elements in Human and Animal Nutrition. W. Mertz (Ed). Academic Press, San Diego, 5th edn., vol. 1. pp 185-223.
- Lenkins, T. G., Leymaster, K.A. & Turbington, L.M. 1988. Estimation of fat-free soft tissue in lamb carcasses by use of carcass and resistive impedance measurements. Journal of Animal Science. 58, 611-618.
- Janeway, C.A. & Travers, P. 1997. Immuno Biology: The Immune System in Health and Disease. Garland Publishing Inc., 717 Fifth Avenue, New York, USA.
- Jelinek, P.D., Ellis, T., Wroth, R.H., Sutherland, S.S., Masters, H.G. & Petterson, D.S. 1988. The effect of selenium supplementation on immunity, and the establishment of an experimental *Haemonchus contortus* infection, in weaner

- Merino sheep fed a low selenium diet. Australian Veterinary Journal. 65, 214-217.
- Jones, D.G. & Suttle, N.F. 1981. Some effects of copper deficiency on leukocyte function in sheep and cattle. Research in Veterinary Science. 31, 151-156.
- Jones, S. D. M. & Haworth, C. R. 1982. The measurement of subcutaneous fat thickness in cold beef carcasses with an automatic probe. Canadian Journal of Animal Science. 62, 645-648.
- Keet, D.F., Kriek, N.P.J., Penrith, M.-L., Michel, A. & Huchzermeyer, H. 1996. Tuberculosis in buffaloes (*Syncerus caffer*) in the Kruger National Park: spread of the disease to other species. Onderstepoort Journal of Veterinary Research. 63, 239-244.
- Kelley, D.S., Daudu, P.A., Taylor, P.C., Mackey, B.E. & Turnlud, J.R. 1995. Effects of low-copper diets on human immune response. American Journal of Clinical Nutrition. 62, 412-416.
- Kempster, A.J., Chadwick, J.P., Cue, R.I. & Grantley-Smith, M. 1984. The estimation of sheep carcass composition from fat and muscle thickness measurements taken by probes. Meat Science. 16, 113-126.
- Kempster, A.J., Chadwick, J.P., Jones, D.W. & Cuthbertson, A. 1981. An evaluation of the Hennessy and Chong Fat Depth Indicator and the Ulster Probe for use in pig carcass classification and grading. Animal Production. 33, 319-324.
- Kempster, A.J., Chadwick, J.P. & Jones, D.W. 1985. An evaluation of the Hennessy Grading Probe and the SFK Fat-O-Meter for use in pig carcass classification and grading. Animal Production. 40, 323-329.

Kennedy, D.G., Young, P.B., Kennedy, S., Scott, J.M., Molloy, A.M., Weir, D.G. & Price, J. 1995. Cobalt-vitamin B₁₂ deficiency and the activity of methyl malonyl CoA mutase and methionine synthase in cattle. *International Journal for Vitamin and Nutrition Research*. 65, 241-247.

Kennedy, S., McConnel, S., Anderson, D.G., Dennedy, D.G., Young, P.B. & Blanchflower, W.J. 1997. Histopathologic and ultrastructural alterations of white liver disease in sheep experimentally depleted of cobalt. *Veterinary Pathology* 34, 575-584.

Kincaid, R.L., Rock, M. & Awadeh, F. 1999. Selenium for ruminants: comparing organic and inorganic selenium for cattle and sheep. *Biotechnology in the Feed Industry. Proceedings of Alltech's 15th Annual Symposium*. Lyons, T.P. and Jacques, K.A. (Eds). pp. 537-545.

Kiremidjian-Schumacher, L., Roy, M., Wishe, H.I., Cohen, M.W. & Stotzky, G. 1990. Selenium and immune cell functions. I. Effect on lymphocyte proliferation and production of interleukin 1 and interleukin 2. *Proceedings of the Society for experimental Biology and Medicine*. 193, 136-142.

Kirton, A.H., Feist, C.L., Duganzich, D.M., Jordan, R.B., O'Donnel, K.P. & Woods, E.G. 1987. Use of the Hennessy Grading Probe (GP) for predicting the meat, fat and bone yields of beef carcasses. *Meat Science*. 20, 51-63.

Klosterman, E.W., Sanford, L.G., & Parker, C.F. 1968. Effects of cow size and condition and ration protein content upon maintenance requirements of mature beef cows. *Journal of Animal Science*. 27, 242 - 246.

Knight, D.A. & Tyznik, W.J. 1990. The effect of dietary selenium on humoral immuno-competence of ponies. *Journal of Animal Science*. 68, 1311-1317.

- Kloeck, P.E. 1998. Tuberculosis of domestic animals in areas surrounding the Kruger National Park. The challenges of managing tuberculosis in wildlife in southern Africa (Zunkel, K. Ed.), 30-31 July, Nelspruit, South Africa. Mpumalanga Parks Board, Nelspruit.
- Koller, L.D., Exon, J.H., Talcott, P.A., Osborne, C.A. & Henningsen, G.M. 1986. Immune response in rats supplemented with selenium. *Clinical and experimental Immunology*. 63, 570-576.
- Kubica, G.P. & Wayne, L.G. 1984. *The Mycobacteria: a sourcebook*. Dekker, New York, 2 v. (xiv, 1553 p.) : ill. ; 27 cm pp.
- Kutsley, J.A., Murphey, C.E., Smith, G.C., Savell, J.W., Stiffler, D.M. & Terrell, R. N. 1982. Use of the Hennessy and Chong fat depth indicator for predicting fatness of beef carcasses. *Journal of Animal Science*. 55, 565-571.
- Larsen, H.J. & Tollersrud, S. 1981. Effect of dietary vitamin E and selenium on the phytohaemagglutinin response of pig lymphocytes. *Research in Veterinary Science*. 31, 301-305.
- Larsen, H.J., Moksnes, K. & Øvernes, G. 1988a. Influence of selenium on antibody production in sheep. *Research in Veterinary Science*. 45, 4-10.
- Larsen, H.J., Øvernes, G. & Moksnes, K. 1988b. Effect of selenium on sheep lymphocyte responses to mitogens. *Research in Veterinary Science*. 45, 11-15.
- Larsen, H.J.S. 1993. Relations between selenium and immunity. *Norwegian Journal of Agricultural Science. Supplement*. 11, 105-119.
- Lawrie, R.A. 1984. *Meat Science*, Fourth edition. Pergamon Press Ltd., Headington Hill Hall, Oxford, England.

- Leach, R.M. Jr. & Harris, E.D. 1997. Manganese. Handbook of Nutritionally Essential Mineral Elements. O'Dell, B.L. and Sunde, R.A. (Eds). Marcel Dekker, New York, pp. 335-356.
- Ledger, H.P. & Smith, N.S. 1964. The carcass and body composition of the Uganda kob. *Journal of Wildlife Management*. 28, 827 – 839.
- Ledger, H.P., Sachs, R. & Smith, N.S. 1967. Wildlife and food production with special reference to the semi-arid areas of tropics and sub-tropics. *Wild. Rev. Animal Production*. III, 13 – 37.
- Lei, X.G., Dann, H.M., Ross, D.A., Cheng, W.-S., Combs, G.F. & Roneker, K.R. 1998. Dietary selenium supplementation is required to support full expression of three selenium-dependent glutathione peroxidases in various tissues of weanling pigs. *Journal of Nutrition*. 128, 130-135.
- Lemenager, R.P., Nelson, L.A. & Hendrix, K.S. 1980. Influence of cow size and breed type on energy requirements. *Journal of Animal Science*. 51, 566.
- Lessard, M., Yang, W.C., Elliott, G.S., Rebar, A.H., Van Vleet, J.F., Deslauriers, N., Brisson, G.J. & Schultz, R.D. 1991. Cellular immune responses in pigs fed a vitamin E- and selenium-deficient diet. *Journal of Animal Science*. 69, 1575-1582.
- Lowmann, B.G., Scott, N.A. & Somerville, S.H. 1976. Condition scoring of cattle. *Bulletin, East of Scotland College of Agriculture, No. 6*.
- MacPherson, A., Gray, D., Mitchel, G.B.B. & Taylor, C.N. 1987. Ostertagia infection and neutrophil function in cobalt-deficient and cobalt-supplemented cattle. *British Veterinary Journal*. 143, 348-355.

- Maddox, J.F., Reddy, C.C., Eberhart, R.J. & Scholz, R.W. 1991. Dietary selenium effects on milk eicosanoid concentrations in dairy cows during coliform mastitis. *Prostaglandins*. 42, 369-378.
- Mahan, D.C. & Kim, Y.Y. 1996. Effect of inorganic and organic selenium at two dietary levels on reproductive performance and tissue selenium concentrations in first parity gilts and their progeny. *Journal of Animal Science*. 74, 536-543.
- Malecki, E.A. & Greger, J.L. 1996. Manganese protects against heart mitochondrial lipid peroxidation in rats fed high levels of polyunsaturated fatty acids. *Journal of Nutrition*. 126, 27-33.
- Martin, J.L. & Spallholz, J.S. 1976. Selenium in the immune response. *Proceedings of Symposium Se-Te in the Environment*. University of Notre Dame, Indiana. 204-211.
- Masters, D.G., Paynter, D.I., Briegel, J., Baker, S.K. & Purser, D.B. 1988. Influence of manganese intake on body, wool and testicular growth of young rams and on the concentration of manganese and the activity of manganese enzymes in tissues. *Australian Journal of Agricultural Research*. 39, 517-524.
- McDonald, P., Edwards, R.A. & Greenhalgh, J.F.D. 1988. *Animal Nutrition 4th edition*. John Wiley & Sons, Inc., 605 Third Avenue, New York, NY 10158.
- McKenzie, R.C., Rafferty, T.S. & Beckett, G.J. 1998. Selenium: an essential element for immune function. *Trends Immunology today*. 19, 342-345.
- Miles, C.A., Fursey, G.A.J. & Pomeroy, R.W. 1983b. Ultrasonic evaluation of cattle. *Animal Production*. 36, 363-370.

- Miles, C.A., Fursey, G.A.J. & York, R.W.R. 1984. New equipment for measuring the speed of ultrasound and its application in the estimation of body composition of farm livestock. in *In Vivo Measurement of Body Composition in Meat Animals*, ed. D. Lister. Elsevier Applied Science Publishers, London, pp. 93-105.
- Miles, C.A. & Fursey, G.A.J. 1974. A note on the velocity of ultrasound in living tissue. *Animal Production*. 18, 93-96.
- Miller, M.F., Cross, H.R., Smith, G.C., Baker, J.F., Beyers, F.M. & Recio, H.A. 1986. Evaluation of live and carcass techniques for predicting beef carcass composition. *Journal of Animal Science*. 63 (Suppl. 1), 234 (Abstract).
- Mitchell, A. D., Wang, P.C. & Elsasser, T.H. 1987. Nuclear magnetic resonance imaging of the pig and spectroscopy of pork tissue. *Journal of Animal Science*. 65 (Suppl.). 259.
- Monro, R.H. 1979. A study on the growth, feeding and body condition of impala *Aepyceros melampus*. M. Sc. Thesis, University of Pretoria.
- Monro, R.H. & Skinner, J.D. 1979. A note on condition indices for adult male impala, *Aepyceros melampus*. *South African Journal of Animal Science*. 9, 47–51.
- Morris, R., Pfeiffer, D., & Jackson, R. 1994. The epidemiology of *Mycobacterium bovis* infections. *Veterinary Microbiology*. 40, 153-177.
- Mulhern, S.A. & Koller, L.D. 1988. Severe or marginal copper deficiency results in a graded reduction of the immune status in mice. *Journal of Nutrition*. 118, 1041-1047.

- Naudé, R.T. 1972. The determination of muscle, fat and bone in carcasses and cuts of young steers. *South African Journal of Animal Science*. 2, 35-39.
- Neiland, K.A. 1970. Weight of dried marrow as indicator of fat in caribou femurs. *Journal of Wildlife Management*. 34, 904-907.
- Nelsen, T.C., Short, R.E., Reynolds, W.L. & Urick, J.J. 1985. Palpated and visually assigned condition scores compared with weight, height and heart girth in Hereford and crossbred cows. *Journal of Animal Science*. 60, 363.
- Nemec, M., Hidioglou, M., Nielsen, K. & Proulx, J. 1990. Effect of vitamin E and selenium supplementation on some immune parameters following vaccination against brucellosis in cattle. *Journal of Animal Science*. 68, 4303-4309.
- Nève, J. 1994. Assessing the biological activity of selenium supplements: Interest of blood selenium and glutathione peroxidase. *Proceedings of STDA's Fifth International Symposium*. Brussels. 123-130.
- Nicholson, J.W.G., Bush, R.S. & Allen, J.G. 1993. Antibody responses of growing beef cattle fed silage diets with and without selenium supplementation. *Canadian Journal of Animal Science*. 73, 355-365.
- Nockels, C.F. 1996. Antioxidants improve cattle immunity following stress. *Animal Feed Science and Technology*. 62, 59-68.
- O'Reilly, L., & Daborn, C. 1995. The epidemiology of *Mycobacterium bovis* infections in animals and man: a review. *Tubercle and Lung Disease*, 76 Suppl 1, 1-46.
- Orr, C.L., Hutcheson, D.P., Grainger, R.B., Cummins, J.M. & Mock, R.E. 1990. Serum copper, zinc, calcium and phosphorus concentrations of calves stressed

by bovine respiratory disease and infectious bovine rhinotracheitis. *Journal of Animal Science*. 68, 2893-2900.

Otto, K.A., Ferguson, J.D., Fox, D.G. & Sniffen, C.J. 1991. Relationship between body condition score and composition of ninth to eleventh rib tissue in Holstein dairy cows. *Journal of Dairy Science*. 74, 852.

Patterson, D.S.P. 1965. The association between depot fat mobilization and the presence of xanthophyll in the plasma of normal sheep. *Journal of Agricultural Science*. 65, 273-278.

Paynter, D. & Caple, I.W. 1984. Age-related changes in activities of the superoxide dismutase enzymes in tissues of the sheep and the effect of dietary copper and manganese on these changes. *Journal of Nutrition*. 114, 1909-1916.

Paynter, D.K. 1979. Glutathione peroxidase and selenium in sheep I. Effect intramuscular selenium pellets on tissue glutathione peroxidase activities. *Australian Journal of Agricultural Research*. 30, 695.

Pherson, B., Knutsson, M. & Gyllensward, M. 1989. Glutathione peroxidase activity in heifers fed diets supplemented with organic and inorganic selenium compounds. *Swedish Journal of Agricultural Research*. 19, 53-57.

Politis, I., Hidioglou, M., Batra, T.R., Gilmore, J.A., Gorewit, R.C. & Scherf, H. 1995. Effects of vitamin E on immune function in dairy cows. *American Journal of Veterinary Research*. 56, 179-184.

Pollock, J.M., McNair, J., Kennedy, S., Kennedy, D.G., Walsh, D.M., Goodall, E.A., Mackie, D.P. & Crockard, A.D. 1994. Effects of dietary vitamin E and selenium on *in vitro* cellular immune responses in cattle. *Research in Veterinary Science*. 56, 100-107.

Preston, T.R. & Willis, M.B. 1974. *Intensive Beef Production*. Pergamon Press, Oxford.

Prohaska, J.R. & Lukasewycz, A. 1990. Effects of copper deficiency on the immune system. *Advances in experimental medicine and biology*. N. Back, et al. (Eds). Plenum Press. Volume 262.

Puls, R. 1994. *Mineral Levels in Animal Health, Diagnostic Data*, Serpa Int., Clearbrook, BC, 2nd edn.

Ransom, A.B. 1965. Kidney and marrow fat as indicators of white-tailed deer condition. *Journal of Wildlife Management*. 29, 397 – 398.

Recio, H.A., Savell, J.W., Cross, H.R. & Harris, J.M. 1986. Use of real-time ultrasound for predicting beef cutability. *Journal of Animal Science*. 63 (Suppl.1), 260 (Abstract).

Reddy, P.G., Morrill, J.L., Minocha, H.C., Morrill, M.B., Dayton, A.D. & Frey, R.A. 1986. Effect of supplemental vitamin E on the immune system of calves. *Journal of Dairy Science*. 69, 164-171.

Reffett, J.K., Spears, J.W. & Brown, Jr. T.T. 1988a. Effect of dietary selenium on the primary and secondary immune response in calves challenged with infectious bovine rhinotracheitis virus. *Journal of Nutrition*. 118, 229-235.

Reffett, J.K., Spears, J.W. & Brown, Jr. T.T. 1988b. Effect of dietary selenium and vitamin E on the primary and secondary immune response in lambs challenged with parainfluenza virus. *Journal of Animal Science*. 66, 1520-1528.

- Riney, T. 1955. Evaluating condition of free-ranging red deer (*Cervus elaphus*), with special reference to New Zealand, parts I and II. N. Z. J. Sci. Tech. B. 36, 429–483.
- Rodwell, T.C. 1999. The epidemiology of bovine tuberculosis in African buffalo. PhD Dissertation. University of California, Davis.
- Rodwell, T.C. Kriek, N.P., Bengis, R.G., Whyte, I.J., Viljoen, P.C., De Vos, V. & Boyce, W.M. 2001. Prevalence of bovine tuberculosis in African buffalo at Kruger National Park. *Journal of Wildlife Diseases*. 37, 258-264.
- Rosen, M.N. & Bischoff, A.I. 1952. The relation of hematology to condition in California deer. *Trans. 17th Norht American Wildlife Conference*. 17, 482 – 496.
- Russel, A.J.F., Doney, J.M. & Gunn, R.G. 1969. Subjective assessment of body fat in live seep. *Journal of Agricultural Science, Cambridge*. 72, 451 – 454.
- Saenko, E.L., Yaroplov, A.I. & Harris, E.D. 1994. Biological functions of caeruloplasmin expressed through copper-binding sites. *Journal of Trace Elements in Experimental Medicine*. 7, 69-88.
- Saker, K.E., Swecker, W.S. & Eversole, D.E. 1994. Effect of copper supplementation and vaccination on cellular immune response in growing beef calves. *Journal of Animal Science*. 72 (Suppl. 1), 131 (Abstr.).
- SAS. 1992. *Statistical Analysis System Users Guide*. Statistical Analysis System Institute Inc., NC.
- Schmitt, S., Fitzgerald, S., Cooley, T., Bruning-Fann, C., Sullivan, L., Berry, D., Carlson, T., Minnis, R., Payeur, J. & Sikarskie, J. 1997. Bovine tuberculosis in

free-ranging white-tailed deer from Michigan. *Journal of Wildlife Diseases*. 3, 749-758.

Scholz, R.W. & Hutchinson, L.J. 1979. Distribution of glutathione peroxidase activity and selenium in the blood of dairy cows. *American Journal of Veterinary Research*. 10, 245.

Schuschke, D.A., Saari, J.T., West, C.A. & Miller, F.N. 1994. Dietary copper deficiency increases the mast cell population of the rat. *Proceedings of the Society for Experimental Biology and Medicine*. 207, 274-277.

Scotcher, J.S.B. 1982. *Interrelations of vegetation and eland in Giant's Castle Game Reserve*. Ph.D. thesis, University of the Witwatersrand, Johannesburg.

Serfass, R.R. & Ganther, H.E. 1975. Defective microbicidal activity in glutathione peroxidase deficient neutrophils of selenium deficient rats. *Nature*. 255, 640-641.

Shackleton, C.M. & Granger, J.E. 1989. Bone marrow fat index and kidney fat index of several antelope species from Transkei. *South African Journal of Wildlife Research*. 19, 129-134.

Simm, G. 1983. The use of ultrasound to predict the carcass composition of live cattle - a review. *Animal Breeding Abstracts*. 51, 853-875.

Sinclair, A.R.E. 1970. *Studies of the ecology of the East African Buffalo*. Ph.D. Thesis, Oxford University.

Sinclair, A.R.E. & Duncan, P. 1972. Indices of condition in tropical ruminants. *East African Wildlife Research*. 10, 143-149.

Smith, N.S. 1970. Appraisal of condition estimation methods for East African ungulates. *East African Wildlife Research*. 8, 123–129.

Smith, N.S. & Ledger, H.P. 1965. A method of predicting liveweight from dissected leg weight. *Journal of Wildlife Management*. 29, 504 – 511.

Spallholz, J.E. 1990. Selenium and glutathione peroxidase: essential nutrient and antioxidant component of the immune system. *Advances in experimental medicine and biology*. Back, et al., (Eds). Plenum Press. Volume 262.

Spallholz, J.E. & Boylan, L.M. 1989. Effects of dietary selenium on peritoneal macrophage chemiluminescence. *Federation Journal*. 3, A778.

Spallholz, J.E., Martin, J.L., Gerlach, M.L. & Heinzerling, R.H. 1973. Enhanced immunoglobulin M and immunoglobulin G antibody titers in mice fed selenium. *Infection and Immunity*. 8, 841-842.

Spector, W.S. (Ed). 1956. *Handbook of biological data*. W.B. Saunders Co., Philadelphia and London. pp 584.

Stabel, J.R., Reinhardt, T.A. & Nonnecke, B.J. 1991. Effect of selenium and reducing agents on *in vitro* immunoglobulin M synthesis by bovine lymphocytes. *Journal of Dairy Science*. 74, 2501-2506.

Stabel, J.R., Spears, J.W. & Brown, Jr. T.T. 1993. Effect of copper deficiency on tissue, blood characteristics, and immune function of calves challenged with infectious bovine rhinotracheitis virus and *Pasteurella hemolytica*. *Journal of Animal Science*. 71, 1247-1255.

Stabel, J.R., Spears, J.W., Brown, Jr. T.T. & Brake, J. 1989. Selenium effects on glutathione peroxidase and the immune response of stressed calves challenged with *Pasteurella hemolytica*. *Journal of Animal Science*. 67, 557-564.

Stelfox, J.B. & Hudson, R.J. 1986. Body condition of male Thompson's and Grant's gazelles in relation to season and resource use. *African Journal of Ecology*. 24, 111-120.

Stewart, S.F., Norden, H.A., Wood, A.J. & Cowan, I. McT. 1964. Changes in the plasma lipids in the black-tailed deer throughout the year. *Proceedings of the International Congress of Zoology*. 2, 46.

Sunde, R.A. 1994. Intracellular glutathione peroxidase – structure, regulation and function. *Selenium in biology and human health*. Burk, R.F. (Ed). Springer Verlag, New York, pp. 45-77.

Suttie, J.M. 1983. The relationship between kidney fat index and marrow fat index as indicators of condition in red deer (*Cervus elaphus*) stags. *Journal of Zoology*, London. 201, 563-565.

Suttle, N.F. 1988. Predicting the risk of mineral deficiencies in grazing animals. *South African Journal of Animal Science*. 18, 15 - 22.

Suttle, N.F. & Jones, D.G. 1986. Copper and disease resistance in sheep: a rare natural confirmation of interaction between a specific nutrient and infection. *Proceedings of the Nutrition Society* 45, 317-325.

Suttle, N.F., Brebner, J., Munro, C.S. & Herbert, E. 1989. Towards an optimum dose of cobalt in anthelmintics in lambs. *Proceedings of the Nutrition Society* 48, 87A.

- Swantek, P.M., Marchello, M.J., Crenshaw, J.D., Lukaski, H.C. & Lewis, A.S. 1989. Bioelectrical impedance: a non-invasive procedure to estimate fat-free mass of market swine. *Journal of Animal Science*. 67 (Suppl.1), 225.
- Swatland, H.J. 1984. Structure and development of meat animals. Prentice- Hall, Inc., Englewood Cleffs, New Jersey.
- Swecker, W.S., Eversole, D.E., Thatcher, C.D., Blodgett, D.J., Schurig, G.G. & Meldrum, J.B. 1989. Influence of supplemental selenium on humoral immune responses in weaned beef calves. *American Journal of Veterinary Research*. 50, 1760-1763.
- Swecker, W.S., Thatcher, C.D., Eversole, D.E., Blodgett, D.J. & Schurig, G.G. 1995. Effect of selenium supplementation on colostral IgG concentration in cows grazing selenium deficient pastures and on post-suckle serum IgG concentration in their calves. *American Journal of Veterinary Research*. 56, 450-453.
- Taber, R.D., White, K.L. & Smith, N.S. 1959. The annual cycle of condition in the Rattlesnake, Montana, mule deer. *Proc. Mont. Acad. Sci.* 19, 72-79
- Taylor, C.G., Bettger, W.J. & Bray, T.M. 1988. Effect of dietary zinc or copper deficiency on the primary free radical defence system in rats. *Journal of Nutrition*. 118, 613-621.
- Terry, C.A., Savell, J.W., Recio, H. A. & Cross, H.R. 1989. Using ultrasound technology to predict pork carcass composition. *Journal of Animal Science*. 67,1279-1284.
- Tessaro, S.V. 1986. The existing and potential importance of brucellosis and tuberculosis in Canadian wildlife: a review. *Canadian Veterinary Journal*. 27, 119-124.

- Tong, J and Malcolm J. W. P. 2002. Pulse echo comparison method with FSUPER to measure velocity dispersion in n-tetradecane in water emulsions. *Ultrasonics*. 40,1-8.
- Turner, R.J. & Finch, J.M. 1990. Immunological malfunctions associated with low selenium-vitamin E diets in lambs. *Journal of Comparative Pathology*. 102, 99-109.
- Turner, R.J. & Finch, J.M. 1991. Selenium and the immune response. *Proceedings of the Nutrition Society*. 50, 275-285.
- Turner, R.J., Wheatly, L.E. & Beck, N.F.G. 1985. Stimulatory effects of selenium on mitogen responses in lambs. *Veterinary Immunology and Immunopathology*. 8, 119-124.
- Underwood, E.J. 1977. *Trace Elements in Human and Animal Nutrition* (4th Ed). Academic Press, New York.
- Van Rooyen, A.F. 1993. Variation in body condition of impala and nyala in relation to social status and reproduction. *South African Journal of Wildlife Research*. 23, 36–38.
- Van Ryssen, J.B.J. 1997. Predicting the trace element status of farm animals, *Proc. 35th Congress South African Society of Animal Science*. Nelspruit. pp 68 – 70.
- Van Ryssen, J.B.J. 2000. The multifactorial nature of trace nutrient nutrition and the supplementation of trace elements to livestock in South Africa, *Proc. 38th Congress of the South African Society of Animal Science*. Alpine Heath, KwaZulu-Natal. pp 253 – 257.

- Van Ryssen, J.B.J., Miller, W.J., Gentry, R.P. & Neathery, M.W. 1987. Effect of Added Dietary Cobalt on Metabolism and Distribution of Radioactive Selenium and Stable Minerals. *Journal of Dairy Science*. 70, 639.
- Varnam, A.H. & Sutherland, J.P. 1995. *Meat and Meat Products: Technology, Chemistry and Microbiology*. Chapman and Hall, Boundary Row, London.
- Vosloo, W., Bastos, A.D.S., Michel, A. & Thomson, G.R. 2001. Tracing movement of African buffalo in southern Africa. *Rev. Sci. Tech. Off. Int. Epiz.* 20, 630-639.
- Wagner, J.J. 1984. Carcass composition in mature Hereford cows: Estimation and influence on metabolizable energy requirements for maintenance during winter. Ph.D. Dissertation. Oklahoma State Univ., Stillwater.
- Ward, J.D., Gengelbach, G.P. & Spears, J.W. 1997. The effects of copper deficiency with or without high dietary iron or molybdenum on immune function of cattle. *Journal of Animal Science*. 75, 1400-1408.
- Whitman, R.W. 1975. Weight change, body condition and beef cow reproduction. Ph.D. Dissertation, Colorado State Univ., Fort Collins.
- Wildman, E.E., Jones, G.M., Wagner, P.E., Boman, R.L., Troutt, Jr. H.F. & Lesch, T.N. 1982. A dairy cow body condition scoring system and its relationship to selected production characteristics. *Journal of Dairy Science*. 65, 495.
- Windhauser, M.M., Dappel, L.C., McClure, J. & Hegsted, M. 1991. Suboptimal levels of dietary copper vary immunoresponsiveness in rats. *Biological Trace Element Research*. 30, 205-209.

- Wong, G.H.W. & Goeddel, D.V. 1988. Induction of manganous superoxide dismutase by tumour necrosis factor: possible protective mechanism. *Science* 242, 941-944.
- Woodford, M.H. 1982. Tuberculosis in wildlife in the Ruwenzori National Park, Uganda. *Tropical Animal Health and Production*. 14, 81-88.
- Woolliams, J.A., Woolliams, C., Suttle, N.F, Jones, D.G. & Wiener, G. 1986. Studies on lambs from lines genetically selected for low or high plasma copper status. 2. Incidence of hypocuprosis on improved hill pasture. *Animal Production*. 43, 303-317.
- Wright, C.L., Corah, L.R., Stokka, G.L. & Blecha, F. 1997. The effects of pre-weaning vitamin E, selenium, and copper supplementation on the performance, acute phase protein concentration, and lymphocyte responsiveness of stressed beef calves. *Journal of Animal Science*. 74 (Suppl. 1), 266 (Abstr.).
- Wright, I.A. & Russel, A.J.F. 1984a. Partition of fat, body composition, and body condition scoring in mature cows. *Animal Production*. 38, 23 - 32.
- Wright, I.A. & Russel, A.J.F. 1984b. Estimation *in vivo* of the chemical composition of the bodies of mature cows. *Animal Production*. 38, 33 - 44.
- Wright, P.L. 1965. Life span of ovine erythrocytes as estimated from selenium-75 kinetics. *Journal of Animal Science*. 11, 546-550.
- Xin, Z., Waterman, D.F., Hemken, R.W. & Harmon, R.J. 1991. Effects of copper status on neutrophil function, superoxide dismutase and copper distribution in steers. *Journal of Dairy Science*. 74, 3078-3085.

Young, W.K., Edwards, L.D. & Hucker, D.A. 1985. Peripheral blood white cell responses during concurrent copper deficiency and gastrointestinal nematodiasis in sheep. *Australian Journal of Experimental Biology and Medical Science*. 63, 273-281.