

REFERENCES

- Abilay, T.A., Johnson, H.D. and Madan, M. 1975. Influence of environmental heat on peripheral plasma progesterone and cortisol during the bovine estrous cycle. *J. Dairy Sci.* 58:1836-1840.
- Al-Katanani, Y.M., Paula-Lopes, F.F. and Hansen, P.J. 2002. Effect of season and exposure to heat stress on oocyte competence in Holstein cows. *J. Dairy Sci.* 85:390-396.
- Al-Katanani, Y.M., Webb, D.W. and Hansen, P.J. 1999. Factors affecting seasonal variation in nonreturn rate to first service in lactating Holstein cows in a hot climate. *J. Dairy Sci.* 82:2611-2616.
- Arave, C.W., Shipka, M.L., Morrow-Tesch, J. and Albringht, J.L. 1996. Changes in serum cortisol following extended lock-up time of lactating cows. *J. Dairy Sci.* 79 (Suppl):244(Abst.)
- Arechiga, C.F., Ealy, A.D. and Hansen, P.J. 1995. Evidence that glutathione is involved in thermotolerance of preimplantation murine embryos. *Biol. Reprod.* 52:1296-1301.
- Armstrong, D. 1994. Heat stress interactions with shade and cooling. *J. Dairy Sci.* 77:2044-2050.
- Armstrong, D., DeNise, S., Delfino, F., Hayes, E., Grundy, P., Montgomery, S. and Correa, M. 1993. Comparing three different dairy cattle cooling systems during high environmental temperatures. *J. Dairy Sci.* 76(Suppl. 1):24. (Abstr.)
- Armstrong, D., Wise, M., Torabi, M., Weirsmas, F., Hunter, R. and Kopel, K. 1988. Effect of different cooling systems on milk production of late lactation Hoistein cows during high ambient temperatures. *J. Dairy Sci.* 71(Suppl. 1):212. (Abstr.)
- Ashutosh, O.P.D. and Kundu, R.L. 2001. Effect of climate on the seasonal endocrine profile of native and crossbred sheep under semi-arid conditions. *Tropical Animal Health and Production* 33:241-252.
- Badinga, L., Collier, R.J., Wilcox, C.J. and Thatcher, W.W. 1985a. Interrelationships of milk yield, body weight and reproductive performance *J. Dairy Sci.* 68:1828-1831.

- Badinga, L., Collier, R.J., Thatcher, W.W. and Wilcox, C.J. 1985b. Effects of climatic and management factors on conception rate of dairy cattle in subtropical environmen. *J. Dairy Sci.* 68:78-85.
- Badinga. L., Thatcher, W.W., Diaz, T., Drost, M. and Wolfenson, D. 1993. Effect of environmental heat stress on follicular development and steroidogenesis in lactating Holstein cows. *Theriogenology* 39:797-810.
- Bauman, D.E. and Currie, W.B. 1980. Partitioning of nutrients during pregnancy and lactation: A review of mechanisms involving homeostasis and homeorhesis. *J. Dairy Sci.* 63:1514-1529.
- Bell, A.W. 1995. Regulation of organic nutrient metabolism during transition from late pregnancy to early lactation. *J. Anim. Sci.* 73:2804-2819.
- Berman, A., Folman, Y., Kaim, M., Marnen, M., Herz, Z., Wolfensen, D., Arieli, A. and Graber, Y. 1985. Upper critical temperature and forced ventilation effects for high-yielding daily cows in a subtropical climate. *J. Dairy Sci.* 68:1488-1495.
- Berman, A. and Wolfenson, D. 1992. Environment modifications to improve production and fertility. In: Van Horn HH and Wilcox CJ (eds), *Large Dairy Herd Management*, Amer Dairy Sci Assoc., 126-134.
- Bucklin, R.A., Turner, L.W., Beede, D.K., Bray, D.R. and Hemken, R.W. 1991. Methods to relieve heat stress for dairy cows in hot, humid climates. *Appl. Eng. Agric.* 7:241-247.
- Butler, W.R., Everett, R.W. and Coppock, C.E. 1981. The relationships between energy balance, milk production and ovulation in postpartum Holstein cows. *J. Anim. Sci.* 53:742-748.
- Butler, W.R. and Smith, R.D. 1989. Interrelationships between energy balance and postpartum reproductive function in dairy cattle. *J. Dairy Sci.* 72: 767-783.
- Cartmill, J.A., Al-Zarkouny, S.Z., Hensley, B.A., Rozell, T.G., Smith, J.F. and Stevenson, J.S. 2001a. An alternative AI breeding protocol for dairy cows exposed to elevated ambient temperature before or after calving or both. *J. Dairy Sci.* 84:799-806.

- Cartmill, J.A., El-Zarkouny, S.Z., Hensley, B.A., Lamb, G.C. and Stevenson, J.S. 2001b. Stage of cycle, incidence, and timing of ovulation, and pregnancy rates in dairy cattle after three timed breeding protocols. *J. Dairy Sci.* 84:1051-1059.
- Collier, R.J., Beede, D.K., Thatcher, W.W., Israel, L.A. and Wilcox, C.J. 1982. Influences of environment and its modification on dairy animal health and production. *J. Dairy Sci.* 65:2213-2227.
- Coppock, C.E., Noller, C.H. and Wolfe, S.A. 1974. Effect of forage-concentrate ration in complete feeds fed ad libitum on energy intake in relation to requirements by dairy cows. *J. Dairy Sci.* 75:1371-1380.
- Ealy, A.D., Drost, M. and Hansen, P.J. 1993. Developmental changes in embryonic resistance to adverse effects of maternal heat stress in cows. *J. Dairy Sci.* 76:2899-2905.
- Flamenbaum, I., Wolfenson, D., Mamen, A. and Berman, A. 1986. Cooling cattle by a combination of sprinkling and forced ventilation and its implementation in the shelter system. *J. Dairy Sci.* 69:3140-3147.
- Francos, G. and Macer, E. 1983. Observations on some environmental factors connected with fertility in heat-stressed cows. *Theriogenology* 19:625-634.
- Fricke, P.M. and Wiltbank, M.C. 1999. Effect of milk production on the incidence of double ovulation in dairy cows. *Theriogenology* 52:1133-1143.
- Fuquay, J.W. 1981. Heat stress as it affects animal production. *J. Anim. Sci.* 52:164-174.
- Gilad, E., Meidan, R., Berman, A., Graber, Y. and Wolfenson, D. 1993. Effect of heat stress on tonic and GnRH-induced gonadotrophin secretion in relation to concentration of estradiol in plasma of cyclic cows. *J. Reprod. Fertil.* 99:315-321.
- Gordon, I., Boland, M.P., McGovern, H. and Lynn, G. 1987. Effect of season on superovulating responses and embryo quality in Holstein cattle in Saudi Arabia. *Theriogenology* 27:231(Abstr.)
- Gwazdauskas, F.C. 1985. Effects of climatic on reproduction in cattle. *J. Dairy Sci.* 68:1568-1578.

- Gwazdauskas, F.C., Thatcher, W.W., Kiddy, C.A., Pape, M.J. and Wilcox, C.J. 1981. Hormonal pattern during heat stress following PGF₂α-tham salt induced luteal regression in heifers. *Theriogenology* 16:271-285.
- Gwazdauskas, F.C., Thatcher, W.W. and Wilcox, C.J. 1973. Physiological, environmental and hormonal factors at insemination which may affect conception. *J. Dairy Sci.* 56:873-877.
- Gwazdauskas, F.C., Wilcox, C.J. and Thatcher, W.W. 1975. Environmental and management factors affecting conception rate in a subtropical environment. *J. Dairy Sci.* 58:88-92.
- Hansen, P.J. Effects of environment on bovine reproduction. 1997. In: *Current therapy in large animal theriogenology*. Philadelphia: WB Saunders, pp.403-415.
- Hansen, P.J. and Arechiga, C.F. 1999. Strategies for managing reproduction in the heat-stressed dairy cow. *J. Anim. Sci.* 77:36-50.
- Her, E., Wolfenson, D., Flamenbaum, I., Folman, Y., Kaim, M. and Berman, A. 1988. Thermal, productive, and reproductive responses of high yielding cows exposed to short-term cooling in summer. *J. Dairy Sci.* 71:1085-1092.
- Holter, J.B., West, J.W. and McGilliard, M.L. 1997. Predicting ad libitum dry matter intake and yield of Holstein cows. *J. Dairy Sci.* 80:2188-2199.
- Holter, J.B., West, J.W., McGilliard, M.L. and Pell, A.N. 1996. Predicting ad libitum dry matter intake and yields of Jersey cows. *J. Dairy Sci.* 79:912-921.
- Howell, J.L., Fuquay, J.W. and Smith, A.E. 1994. Corpus luteum growth and function in lactating Holstein cows during spring and summer. *J. Dairy Sci.* 77:735-739.
- Ingraham, R.H., Stanley, R.W. and Wagner, W.C. 1976. Relationship of temperature and humidity to conception rate of Holstein cows in Hawaii. *J. Dairy Sci.* 59:2086-2090.
- Jolly, P.D., McDougall, S., Fitzpatrick, L.A., Macmillan, K.L. and Enwhitsle, K. 1995. Physiological effects of under nutrition on postpartum anoestrous in cows. *J. Reprod. Fertil. Suppl.* 49:477-492.
- Jonsson, N.N., McGowan, M.R., McGuigan, K., Davison, T.M., Hussain, A.M. and Kafi, M. 1997. Relationship among calving season, heat load, energy balance and

- postpartum ovulation of dairy cows in a subtropical environment. *Anim. Reprod. Sci.* 47:315-326.
- Legates, J.E., Farthing, B.R., Casady, R.B. and Barrada, M.S. 1991. Body temperature and respiratory rate of lactating dairy cattle under field and chamber conditions. *J. Dairy Sci.* 74:2491-2500.
- Lucy, M.C., Savio, J.D., Badinga, L., de la Sota, R.L. and Thatcher, W.W. 1992. Factors that affect ovarian follicular dynamics in cattle. *J. Anim. Sci.* 70:3615-3626.
- Madan, M.L. and Johnson, H.D. 1973. Environmental heat effects on bovine luteinizing hormone. *J. Dairy Sci.* 56:1420-1423.
- Mallonee, P.G., Beede, D.K., Collier, R.J. and Wilcox, C.J. 1985. Production and physiological responses of dairy cows to varying dietary potassium during heat stress. *J. Dairy Sci.* 68:1479-1487.
- Maust, L.E., McDowell, R.E. and Hooven, N.W. 1972. Effect of summer weather on performance of Holstein cows in three stages of lactation. *J. Dairy Sci.* 55:1133-1139.
- McGuire, M.A., Beede, D.K., DeLorenzo, M.A., Wilcox, C.J., Huntington, G.B., Reynolds, C.K. and Collier, R.J. 1989. Effects of thermal stress and level of feed intake on portal plasma flow and net fluxes of metabolites in lactating Holstein cows. *J. Anim. Sci.* 67:1050-1060.
- Mihm, M., Curran, N., Hyttel, P., Knight, P.G., Boland, M.P. and Roche, J.F. 1999. Effect of dominant follicle persistence on follicular fluid oestradiol and inhibin and on oocyte maturation in heifers. *J. Reprod. Fertil.* 116:293-304.
- Moody, E.G., Van Soest, P.J., McDowell, R.E. and Ford, G.L. 1971. Effect of high temperature and dietary fat on milk fatty acids. *J. Dairy Sci.* 54:1457-1460.
- Monty, D.E. and Racowsky, C. 1987. In vitro evaluation of early embryo viability and development in summer heat-stressed, superovulated dairy cows. *Theriogenology* 28:451-465.
- Moreira, F., Orlandi, C., Risco, C.A., Mattos, R., Lopes, F. and Thatcher, W.W. 2001. Effects of presynchronization and bovine somatotropin on pregnancy rates to a

- timed artificial insemination protocol in lactating dairy cows. *J. Dairy Sci.* 84:1646-1659.
- National Research Council. 1989. *Nutrient requirements of dairy cattle*. 6th rev. ed. Natl. Acad. Sci., Washington, D.C., pp.157.
- Nebel, R.L., Jobst, S.M., Dransfield, M.B.G., Pandolfi, S.M. and Balley, T.L. 1997. Use of radio frequency data communication system, HeatWatch, to describe behavioural estrus in dairy cattle. *J. Dairy Sci.* 179(Abst.)
- Nebel, R.L. and McGilliard, M.L. 1993. Interactions of high milk yield and reproductive performance in dairy cows. *J. Dairy Sci.* 76:3257-3268.
- Pursley, J.R., Fricke, P.M., Garverick, H.A., Kesler, D.J., Ottobre, J.S., Stevenson, J.S. and Wiltbank, M.C. 2001. Improved fertility in noncycling lactating dairy cows treated with exogenous progesterone during Ovsynch. *J. Dairy Sci.* 83(Suppl. 1):1563.(Abstr.)
- Pursley, J.R., Mee, M.O. and Wiltbank, M.C. 1995. Synchronization of ovulation in dairy cows using PGF_{2α} and GnRH. *Theriogenology* 44:915-923.
- Pursley, J.R., Kosorok, M.R. and Wiltbank, M.C. 1997a. Reproductive management of lactating dairy cows using synchronization of ovulation. *J. Dairy Sci.* 80:301-306.
- Pursley, J.R., Wiltbank, M.C., Stevenson, J.S., Ottobre, J.S., Garverick, H.A. and Anderson, L.L. 1997b. Pregnancy rates per artificial insemination for cows and heifers inseminated at a synchronized ovulation or synchronized estrus. *J. Dairy Sci.* 80:295-300.
- Putney, D.J., Drost, M. and Thatcher, W.W. 1988. Embryonic development in superovulated dairy cows exposed to elevated ambient temperatures between Days 1 to 7 post insemination. *Theriogenology* 30:195-209.
- Putney, D.J., Drost, M. and Thatcher, W.W. 1989a. Influence of heat stress on pregnancy rates of lactating dairy cattle following embryo transfer or artificial insemination. *Theriogenology* 31:765-778.
- Putney, D.J., Mullins, S., Thatcher, W.W., Drost, M. and Gross, T.S. 1989b. Embryonic development in superovulated dairy cattle exposed to elevated ambient

- temperatures between the onset of estrus and insemination. *Anim. Reprod. Sci.* 19:37-51.
- Ravagnolo, O., Misztal, I. and Hoogenboom, G. 2000. Genetic component of heat stress in dairy cattle, development of heat index function. *J. Dairy Sci.* 83:2120-2125.
- Richardson, C.W., Johnson, H.D., Gehrke, C.W. and Goerlitz, D.F. 1961. Effects of environmental temperature and humidity on the fatty acid composition of milk fat. *J. Dairy Sci.* 44:1937-1940.
- Rivera, R.M. and Hansen, P.J. 2001. Development of cultured bovine embryos after exposure to high temperatures in the physiological range. *Reproduction* 121:107-115.
- Roberts, A.J., Nugent III, R.A., Klindt, J. and Jenkins, T.G. 1997. Circulating insulin-like growth factor I, insulin-like growth factor binding proteins, growth hormone, and resumption of estrus in postpartum cows subjected to dietary energy restriction. *J. Anim. Sci.* 75:1909-1917.
- Rocha, A., Randel, R.D., Broussard, J.R., Lim, J.M., Blair, R.M., Roussel, J.D., Godke, P.A. and Hansel, W. 1998. High environmental temperature and humidity decrease oocyte quality in *Bos Taurus* but not in *Bos indicus* cows. *Theriogenology* 49:657-665.
- Roman-Ponce, H., Thatcher, W.W., Buffington, D.E., Wilcox, C.J. and Van Horn, H.H. 1977. Physiological and production responses of dairy cattle to a shade structure in a subtropical environment. *J. Dairy Sci.* 66:424-430.
- Roman-Ponce, H., Thatcher, W.W., Caton, D., Barron, D.H. and Wilcox, C.J. 1978. Thermal stress effects on uterine blood flow in dairy cows. *J. Anim. Sci.* 46:175-180.
- Roman-Ponce, H., Thatcher, W.W. and Wilcox, C.J. 1981. Hormonal relationships and physiological responses of lactating dairy cows to a shade management system in a subtropical environment. *Theriogenology* 16:139-154.
- Ryan, D.P., Prichard, J.F., Kopel, E. and Godke, R.A. 1993. Comparing early embryonic death in dairy cows during hot and cool seasons of the year. *Theriogenology* 39:719-737.

- Ryan, D.P., Scland, M., Kopel, E., Armstrong, D., Munyakazi, L., Gorlke, G. and Ingergam, R. 1992. Evaluating two different evaporative cooling management systems for dairy cows in hot dry climate. *J. Dairy Sci.* 76(Suppl. 1):240. (Abstr.)
- Santos, J.E.P., Thatcher, L., Pool, L. and Overton, M.W. 2001. Effect of human chorionic gonadotropin on luteal function and reproductive performance of high-producing lactating Holstein dairy cows. *J. Anim. Sci.* 79:2881-2894.
- Sartori, R., Sartor-Bergfelt, R., Mertens, S.A., Guenther, J.N., Parrish, J.J. and Wiltbank, M. C. 2000. Early embryonic development during summer in lactating dairy cows and nulliparous heifers. *Biol. Reprod.* 62:(Suppl 1):155 (Abstr).
- Schillo, K.K. 1992. Effect of dietary energy on control of luteinizing hormone secretion in cattle and sheep. *J. Anim. Sci.* 70:1271-1282.
- Simpson, R.B., Armstrong, J.D. and Harvey, R.W. 1992. Effect of prepartum administration of growth hormone-releasing factor on somatotropin, insulin-like growth factor I, milk production, and postpartum return to ovarian activity in primiparous beef heifers. *J. Anim. Sci.* 70:1478-1487.
- Smith, J., Armstrong, D., Correa, A., Auendens, L., Rubio, A. and DeNise, S. 1993a. Effects of spray and fan system on milk production and reproductive efficiency in hot arid climate. *J. Dairy Sci.* 76(Suppl. 1):240. (Abstr.)
- Smith, W.A., Harris, B., Van Horn, Jr. H.H. and Wilcox, C.J. 1993b. Effect of forage type on production of dairy cows supplemented with whole cottonseed, tallow, and yeast. *J. Dairy Sci.* 76:205.
- Spicer, L.J., Tucker, W.B. and Adams, G.D. 1990. Insulin-like growth factor-I in dairy cows: Relationships among energy balance, body condition, ovarian activity, and estrous behavior. *J. Dairy Sci.* 73:929-937.
- Spicer, L.J., Vernon, R.K., Tucker, W.B., Wettemann, R.P., Hogue, J.F. and Adams, G.D. 1993. Effects of inert fat on energy balance, plasma concentrations of hormones and reproduction in dairy cows. *J. Dairy Sci.* 76:2664-2673.
- Staples, C.R., Thatcher, W.W. and Clark, J.H. 1990. Relationship between ovarian activity and energy status during the early postpartum period of high producing dairy cows. *J. Dairy Sci.* 73:938-947.

- Stevenson, J.S., Lamb, G.C., Kobayashi, Y. and Hofman, D.P. 1998. Luteolysis during two stages of the oestrous cycle: Subsequent endocrine profiles associated with radiotelemetrically detected estrus in heifers. *J. Dairy Sci.* 81:2897-2903.
- Stott, G.H. 1981. What is animal stress and how is it measured. *J. Anim. Sci.* 52:150-153.
- Sugiyama, S., McGowan, M., Kafi, M., Phillips, N. and Yong, M. 2003. Effects of increased ambient temperature on the development of in vitro derived bovine zygotes. *Theriogenology* 60:1039-1047.
- Tenhagen, B.A., Drillich, M. and Heuwieser, W. 2001. Analysis of cow factors influencing conception rates after two timed breeding protocols. *Theriogenology* 56:831-838.
- Thatcher, W.W. and Collier, R.J. 1986. Effect of climate on bovine reproduction. In: *Current Therapy in Theriogenology*, Morrow, D.A. (ed). Philadelphia: WB Saunders Co, pp.301-309.
- Thatcher, W.W., Gwazdauskas, F.C., Wilcox, C.J., Toms, J. Head, H.H., Buffington, D.E. and Frederickson, W.B. 1974. Milking performance and reproductive efficiency of dairy cows in an environmentally controlled structure. *J. Dairy Sci.* 57:304-307.
- Thompson, J.A., Magee, D.D., Tomaszewski, M.A., Wilks, D.L. and Fourdraine, R.H. 1996. Management of summer infertility in Texas Holstein dairy cattle. *Theriogenology* 46:547-558.
- Ulberg, L.D. and Burfening, P.J. 1967. Embryo death resulting from adverse environment on spermatozoa or ova. *J. Anim. Sci.* 26:571-577.
- Ulberg, L.D. and Sheenan, L.A. 1973. Early development of mammalian embryos in elevated temperature. *J. Reprod. Fertil.* 19:155-161.
- Vasconcelos, J.L.M., Silcox, R.W., Lacerda, J.A., Pursley, J.R. and Wiltbank, M.C. 1997. Pregnancy rate, pregnancy loss, and response to heat stress after AI at 2 different times from ovulation in dairy cows. *Biol. Reprod.* 56(Suppl 1):230.
- Vasconcelos, J.L.M., Silcox, R.W., Rosa, G.L.M, Pursley, J.R. and Wiltbank, M.C. 1999. Synchronization rate, size of the ovulatory follicle, and pregnancy rate after synchronization of ovulation beginning on different days of the estrus cycle in lactating dairy cows. *Theriogenology* 52:1067-1078.

- West, J.W. 2003. Effects of heat-stress on production in dairy cattle. *J. Dairy Sci.* 86:2131-2144.
- West, J.W., Mullinix, B.G. and Bernard, J.K. 2003. Effects of hot, humid weather on milk temperature, dry matter intake, and milk yield of lactating dairy cows. *J. Dairy Sci.* 86:232-242.
- Williams, G.L. 1990. Suckling as a regulator of postpartum rebreeding in cattle: A review. *J. Anim. Sci.* 68:831-852.
- Wilson, S.J., Kirby, C.J., Koeningsfield, A.T., Keisler, D.H., Lucy, M.C. 1998a. Effects of a controlled heat stress on ovarian function of dairy cattle. 2. Heifers. *J. Dairy Sci.* 81:2132-2138.
- Wilson, S.J., Marion, R.S., Spain, J.N., Spiers, D.E., Keisler, D.H. and Lucy, M.C. 1998b. Effects of a controlled heat stress on ovarian function of dairy cattle. 1. Lactating cows. *J. Dairy Sci.* 81:2124-2131.
- Wiltbank, M.C., Gumen, A. and Sartori, R. 2002. Physiological classification of anovulatory conditions in cattle. *Theriogenology* 57:21-52.
- Wise, M.E., Armstrong, D.V., Huber, J.T., Hunter, R. and Wiersma, F. 1988. Hormonal alterations in the lactating dairy cow in response to thermal stress. *J. Dairy Sci.* 71:2480-2485.
- Wolfenson, D., Lew, B.J., Thatcher, W.W., Graber, Y. and Meidan, R. 1997. Seasonal and acute heat stress effects on steroid production by dominant follicles in cows. *Anim. Reprod. Sci.* 47:9-19.
- Wolfenson, D., Thatcher, W.W., Badinga, L., Savio, J.D., Meidan, R., Lew, B.J., Braw-Tal, R. and Berman, A. 1995. Effect of heat stress on follicular development during the estrous cycle in lactating dairy cattle. *Biol. Reprod.* 52:1106-1113.
- Younas, M., Fuquay, J.W., Smith, A.E. and Moore, A.B. 1993. Estrous and endocrine responses of lactating Holsteins to forced ventilation during summer. *J. Dairy Sci.* 76:430-436.

CURRICULUM VITAE

The author of this thesis, Mr. Siriwat Suadsong, was born on November 18, 1968 in Bangkok Province, Thailand. He completed his primary and secondary education in Singburi Province. After that, he became a student in the Faculty of Veterinary Science at Chulalongkorn University, where he graduated the second class honors of Doctor of Veterinary Medicine (D.V.M.) degree in 1993. He worked as veterinarian in the Department of Veterinary at the Dairy Farming Promotion Organization of Thailand from 1993 to 1995. Thereafter, he has become a staff member of the Department of Obstetrics Gynaecology and Reproduction, Faculty of Veterinary Science, Chulalongkorn University in February 1995. His major responsibilities are teaching veterinarian students and serving in the Faculty's Farm Animal Hospital. He studied at the Department of Obstetrics Gynaecology and Reproduction, Faculty of Veterinary Science, Chulalongkorn University, Bangkok, Thailand, for his Master of Science in Theriogenology during 1998 to 2000 and for his Doctor of Philosophy Program in Theriogenology from 2000 to 2006. He accomplished his Ph.D. title with the research described in this thesis.

