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Status of Surra in Livestock in Thailand

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ABSTRACT

Surra was first detected in mules in Rachaburi province, Thailand in 1949 but it is now known to occur throughout Thailand not only in horses, but also in cattle, buffaloes, pigs, dogs and deer with varying clinical manifestations. The most severe clinical cases usually occurs in infected horses. Abortion at late stages of pregnancy or premature parturition have been reported in infected buffaloes, cattle and pigs. Nervous signs caused by *Trypanosoma evansi* invading the central nervous system have also been observed in infected cattle and more recently in hog deer.

Prevalence rates for this disease vary between 12.5%, 20% and 4.6% in cattle, buffaloes and pigs, respectively. The economic losses caused by surra are considerable, particularly where they impact upon the small holder farmer. These losses accrue through the effects of disease upon piglet and calf production, loss of draught power in buffalo and the reduction in meat and milk production in infected animals. Although no estimates of these costs has yet been realized, it has been suggested that the cost of treatment with trypanocidal drugs in order to control the disease would be substantial, in the order of US$ 7.6 million. More effort is required to determine the extent of the losses in livestock productivity due to trypanosomosis and the benefits of intervention.

INTRODUCTION

Since Evans published the earliest reports on *Trypanosoma evansi* which was endemic in horses and camels in Punjab, India in 1880, the disease due to this parasite has been described by many authors in various parts of the world (Mahmoud and Gray 1980). Surra was first detected in mules in Rachaburi province, Thailand in 1949 (Sananraksat 1949). Following this first reported case, many outbreaks in horses and in 1956 the disease was regulated as a notifiable disease in Thailand under the Animal Epidemic Act A.D. 1956. Subsequently, surra has been reported throughout Thailand not only in horses, but also in cattle, buffaloes, pigs, dogs and deer with varying clinical manifestations. Economic losses in the infected animals are thought to be important, since the farming systems are changing from small holder farms to large production farms.

EPIDEMIOLOGY

In 1975, four thoroughbred mares at the Military Unit in Nakorn-Rachasima province that presented with clinical signs including inappetence, intermittent fever, anemia and oedema were found to be suffering from *T. evansi* that was detected by fresh blood smear and mouse inoculation test (MIT) (Boonyawong et al. 1975). The occurrence of *T. evansi* in other animal species was noted when Matias and Muangyai (1980) reported on *T. evansi* in a 24 day old buffalo calf without any clinical signs.

Field investigations on surra were first carried out in 1,396 swamp buffaloes in the

Northeast in 1981 (Lohr et al. 1985). About 20% of the buffaloes tested positive for *T. evansi* antibodies by complement fixation test, with a distinct peak of infections occurring during the rainy season. From 1984 to 1989 the occurrence of *T. evansi* in animals was studied at the Northeast Regional Veterinary Diagnostic Centre, Khonkaen (Kashemsant et al. 1989). There were more than 92 outbreaks of surra in nine provinces. The infection rate with *T. evansi* using parasitological techniques in cattle, buffaloes, horses and dogs was 13%, 20%, 57% and 100%, respectively. There were no reports on the occurrence of surra in pigs in this region. Nishikawa et al. (1990) conducted a countrywide survey on surra in buffaloes and cattle using the indirect fluorescent antibody test (IFAT). They found that the prevalence rate in buffaloes and cattle by IFAT was 38.6% and 50%, respectively. The highest prevalence of the disease in buffaloes was in the North (57.4%) and the lowest was in the South (28.7%), whereas in cattle, the highest prevalence was in the Central region (64.7%) and the lowest was in the Northeast (28.9%). Other outbreaks of surra in cattle and buffaloes were reported by Trisanarom et al. (1987), Indrakamhang et al. (1982), Patchimasiri et al. (1983) and Chaichanapunpol et al. (1987) (Table 1).

Table 1. Infection rate of surra in Thailand

Year	Animal species	Region	No. of samples examined	% positive	Tests	Reporters
1981	Buffalo	Northeast	1145 1145	16.6 5.3	CFT Parasitology	Lohr et al. 1985
1984-1989	Buffalo Cattle Horse Dog	Northeast	561 479 33 9	20 13 57 100	Parasitology	Kashemsant et al. 1989
1988	Buffalo Cattle	All	531 428	38.6 50.0	IFAT	Nishikawa et al. 1990

Although surra in Thailand was first found in 1949, the first case in pigs was not reported until 1984; pigs on a breeding farm in Pitsanulok province became sick with intermittent fever, anorexia, urticarial plaques on the ventral part of the body, udders, scrotum and ears. *Trypanosoma evansi* was detected in sows, boars and fattening pigs (Teeraprasert et al. 1984a). Later on many outbreaks were reported in the Central region and *T. evansi* caused more serious economic losses in sows than in fattening pigs (Tepsumetanon et al. 1984, Teeraprasert et al. 1984, Sirivan et al. 1987, Sirivan et al. 1994). Previously, more and more cases of surra were found. The results of a survey for surra in cattle, buffaloes and pigs examined at Parasitology Section, National Institute of Animal Health in 1997 were about 12.5%, 20% and 4.6%, respectively.

Not only domesticated livestock but also deer were found to be infected with *T. evansi*. In March 1996 an outbreak of surra occurred on a deer farm in Ayuthaya province in the Central region, where sambar deer or native deer (*Cervus unicolor*) and rusa deer (*C. timorensis*) were raised (Indrakamhang et al. 1996). A survey on surra in captive Thai elephants (*Elephas maximus indicus*) which came to join the Annual Elephant Festival in Surin province in 1995 and 1996 was conducted by Tuntasuvan et al. (1997).

Blood and serum samples were taken from 115 elephants and they reported that while all were negative for *T. evansi* by blood smear, microhaematocrit test and MIT, four samples were serological positive by IFAT and Ab-ELISA.

IDENTIFICATION

Two other species of non pathogenic trypanosomes have been reported from Thailand; *T. theileri* has been found in cattle and buffaloes in the Northeast as single infection or mixed infections with *T. evansi* and *T. melophagium* has been detected in sheep imported from India (Pholpark 1996). However, the pathogenic trypanosomes isolated from various species of animals in Thailand have been identified as *T. evansi*. Sarataphan et al. (1987) characterized trypanosomes found in the blood smears of three sows in Saraburi province and from each of cow, dog and horse in Khonkaen province by measurement of several parameters, including body length, length of flagellum and length of posterior end to kinetoplast, and concluded that there were no significant differences among the various isolates: all were identified as *T. evansi*. Intra-species differentiation of six isolates of *T. evansi* collected from cattle was obtained by DNA fingerprinting with arbitrary primers polymerase chain reaction (AP-PCR). Only one of ten randomly designed 12-mer primers could generate the DNA fingerprints profiles that showed the intra-species differences (Watanapokasin et al. 1997).

TRANSMISSION

Tabanus spp. are probably the most important vectors of *T. evansi*, whereas stable flies (*Stomoxys calcitrans*), *Chrysops* sp. and *Haematopota* sp. are less important. Studies on the vector were carried out on a cattle farm in Patoomthani province where trypanosomosis outbreaks occurred from June 1994 to July 1995 (Bunchit et al. 1996). Five species of tabanids were identified; including *T. megalops*, *T. rubidus*, *T. rufiscutellatus*, *T. striatus* and *T. oxybeles* in the percentage of 65.5, 29.7, 3.1, 0.7 and 0.2, respectively. Tabanids were found throughout the year but they were most abundant from June to October. They gradually decreased in numbers towards March and then began to increase again in April. According to the meteorological data, the high tabanid population coincided with the wet season.

A survey of tabanid flies in Thailand, including some 30 provinces took place during 1994-1996. It was reported that there were 45 species of tabanids comprising three genera, *Tabanus*, *Haematopota* and *Crysops*. *Tabanus rubidus* was found most frequently and distributed in every part of the country and present in 25 provinces. The second most frequent species was *T. striatus*, found in the North and the Central region. *Tabanus megalops* was found only in the Central region (Ito 1996). Although pig farms had low populations of *Tabanus*, surra outbreaks still occurred. In these cases trypanosomosis was considered to have been transmitted mechanically.

CLINICAL SIGNS & PATHOLOGY

Clinical signs in animals infected with *T. evansi* are varied, depending on the animal species. The signs in infected horses are depression, inappetence, intermittent fever, aneamia, icterus, oedema and ecchymotic hemorrhage of some parts of bulbar, palpebral conjunctiva and oedema of subcutaneous tissues of the legs, brisket and belly. Eventually, if untreated, they die (Boonyawong et al. 1975). The most severe cases usually occur in horses; whilst chronic cases occur mostly in infected buffaloes and cattle which sometimes do not show any clinical signs (Matias and Muangyai 1980, Pholpark et al. 1984). However, abortion at late pregnancy or early parturition caused by *T. evansi* occurs in buffaloes (Timsad et al. 1985, Lohr et al. 1986). In dairy cattle, abortion can occur from the fourth months of pregnancy until early calving (Trisanarom et al. 1987). The cattle show retention of placenta, high fever and decreased milk yield. Chaichanapunpol et al. (1987) demonstrated *T. evansi* in blood smear from the heart of an aborted calf. In buffaloes, stress factors such as fasciolosis combined with seasonal malnutrition during the dry season, lower the resistance of the animals causing, exacerbation of clinical trypanosomosis (Lohr et al. 1985).

The effect of *T. evansi* on milk production of dairy cattle was studied on a farm in Nakornpathom province during an outbreak of surra. The prevalence rates on the farm were 80.8% and 100% by parasitological methods and IFAT respectively. About 24% of the infected cows stopped lactating because of the sickness. The milk yield of the infected cows declined gradually by 20.9% and 35.5% in the first peak and second peak of the chronic cases respectively (Sarataphan et al. 1989).

Sporadic outbreaks of *T. evansi* infection in cattle in Thailand have been reported for a number of years but there have been few reports of animals with nervous signs. During the late rainy season and winter season in 1990, outbreaks of suspected trypanosomosis in native cattle (*Bos indicus*) occurred on 13 farms in Petchaboon province. Forty two cattle died with nervous symptoms including; circling, excitation, jumping, aggressive behavior, lateral recumbency, convulsion and finally death. The infection rate of surra on one farm was 100% by MIT and IFAT. In three cattle which died with nervous signs, parasites were found not only in blood smears but also in cerebrospinal fluid smears. Using impression smears stained with Giemsa's stain, *T. evansi* could be demonstrated in nervous tissue from the cerebrum (Tuntasuvan et al. 1997). This finding suggested that the parasite was able to pass through the central nervous system (CNS) as observed experimentally by Sudarto et al. (1990). Recently nervous signs caused by the parasites have also been observed in hog deer in Samuth-Prakarn province.

The clinical signs in pigs infected experimentally with *T. evansi* are inappetence, undulant fever, petechial hemorrhages on the skin of the ears, breasts, legs and scrotum in boars. Some pregnant sows abort and some infected pigs show nervous signs; convulsion and death. However, infected fattening pigs show no clinical signs (Teeraprasert et al. 1984b). In experimentally infected pregnant sows, animals had no appetite on day 3 after infection and on day 4 the body temperature increased to 105.8°F and they aborted. The clinical signs in infected deer were similar to those in infected cattle; including inappetence, weakness, fever, lameness, convulsion and death. There was no significant reduction in PCV in infected deer (Indrakamhang et al. 1996). Hence in acute, clinical disease, abortion, central nervous system disorder and even death can occur, while in chronic conditions, working capacity and productivity of the animals are more likely to be affected. The involvement of the CNS in trypanosomosis caused by *T. evansi* in the infected cattle, pigs and deer needs more study, particularly in relation to the causes of nervous signs and passage through blood brain barrier.

DIAGNOSIS

The diagnosis of surra relies principally on the detection of *T. evansi* in thin blood smears stained with Giemsa's stain or by inoculation into rodents (MIT). For the identification and isolation of *T. evansi* in blood or tissue, fresh material is required.

Tuntasuvan et al. (1997) determined the viability of *T. evansi* in EDTA blood and brain tissue after keeping blood and tissues at +4°C for 1/2, 24 and 30 hours. It was found that while parasites in EDTA blood could be isolated by MIT for up to 24 hours, the parasites could not be isolated from any tissues by MIT within 30 minutes of collection.

In 1982, a complement fixation test (CFT) was developed specially for the detection of antibodies to *T. evansi* in cattle and buffaloes (Lohr et al. 1985). Later, Nishikawa et al. (1990) used IFAT in the survey of surra in cattle and buffaloes. Tuntasuvan et al. (1997) compared the sensitivity and specificity of IFAT and parasitological methods in infected cattle. Those cattle that were shown positive by MIT, were tested with wet blood film, haematocrit centrifuge test, thin blood smear, and IFAT and gave detection rates of 6.3%, 43.8%, 43.8% and 100% respectively. Hence IFAT was the most sensitive test, as reported elsewhere by Monzon et al. (1990).

Tuntasuvan et al. (1996) used crude somatic *T. evansi* antigen as described by Luckins (1970) for use in ELISA for the detection of antibody against *T. evansi* in pigs. Antibodies could be detected in an experimentally infected pig by day 17 postinfection until the end of the study (day 76 postinfection). In pigs naturally infected with *T. evansi*, the assay also gave positive results with high OD values; the test had a specificity of 95% and there were also no cross reactions to pigs infected with *Toxoplasma* or *Eperythrozoon*. The assay was found to be very valuable in cerebral trypanosomosis cases, when the parasites accumulate in nervous tissues and cannot be detected in blood (unpublished data).

Wuyts et al. (1994) developed a polymerase chain reaction (PCR)-based detection technique with a sensitivity of 0.5 pg of parasite DNA (equivalent to one single parasite in 10 μl of clotted blood sample). DNA primer, pMUTec 6.258 was used and the specific band was 227 bp on agarose gels (Chokesajjawatee, 1993). The test made it possible to detect infections in livestock on day 2 postinfection. In addition, it could be used to distinguish treated animals from untreated animals because the PCR signals in an experimentally infected cow disappeared between 6 and 12 hours after treatment.

TREATMENT & CONTROL

Three trypanocidal drugs are available in Thailand; diminazene aceturate (Berenil^R), isometamidium chloride (Samorin^R or Trypamidium^R) and napthylamine sulphonate (Naganol^R). The efficacy of Berenil and Samorin in the treatment of surra was studied in rats experimentally infected with *T. evansi* by Sarataphan et al. (1992). The infected rats were divided into 8 groups. At high parasitaemia the rats in group 1, 2, 3 and 4 were treated with Berenil at 3.5, 8, 10 and 20 mg/kg and *T. evansi* was disappeared from the blood within 24, 20, 8 and 3 hours post treatment, respectively. Infected rats in the other 4 groups were treated with Samorin at 0.5, 1.0, 2.0 and 3.0 mg/kg, where *T. evansi* was cleared from the bloodstream on day 3, 3, 3 and 2 post treatment respectively. Berenil at 3.5 mg/kg could cure rats inoculated with *T. evansi* on day 7, but not on day 14, 30 and 60 of the experiment. No rats died after treatment on day 7 but survival was only 75% and 50% on day 14 and 30 respectively. However, all rats treated with samorin died on day 60.

Field studies on the efficacy of Berenil and Samorin were carried out on a farm where *T. evansi* was endemic (Tuntasuvan et al. 1992). Although Berenil at 3.5 mg/kg or Samorin at 1.0 mg/kg could clear *T. evansi* from the bloodsteam of naturally infected cattle by six hours post treatment, trypanosomes reappeared in some animals three months later. The percentage of positive animals at this time was 25% and 18.2% respectively. It was not known, if these infections were relapses or represented a new infection. Even in infected cattle with nervous symptoms, after treatment with Berenil at 3.5 mg/kg no more cattle died and *T. evansi* was no longer detected in blood samples two months post treatment (Tuntasuvan et al, 1997).

The effective dose of Berenil in infected buffaloes is different from infected cattle. Pholpark et al. (1984) treated experimentally infected buffaloes with Berenil at 5 mg/kg. They found that the parasites could be detected from the infected buffaloes after treatment. The most suitable dose of Berenil in treating the naturally infected buffaloes was 8 mg/kg (Kashemsant et al. 1989). However, 5% of the treated buffaloes were positive at week 2 post treatment. In contrast, parasites could not be detected in the infected buffaloes from week 0 to week 16 after treatment with Samorin 0.5 mg/kg. Sirivan et al. (1994) studied the efficacy of Berenil and Samorin in infected pigs. They reported that infected sows treated with Berenil at 3.5 mg/kg were all clear of parasites by MIT on day 1 post treatment, whereas 37% and 87% of the treated pigs were still positive with *T. evansi* after treatment with Samorin at 0.5 mg/kg and 1.0 mg/kg respectively.

The control of the disease requires treatment of infected animals with effective drugs and reducing blood sucking flies by regular insecticide treatment. To prevent outbreak of disease, it is important to carry out countrywide surveys where endemic areas of surra occur. From the earlier studies it is evident that outbreaks often occurred during the late rainy season and early winter season (from October to February) when fly activity was high and large numbers of *Tabanus* spp. were found (Table 2).

Table 2. Retrospective study on the occurrence of surra outbreaks in Thailand 1983-1996

Month	Province	Animal species	Authors
Aug. 83	Surin (NE)	Buffalo	Timsad et al. 1985
May - Jun. 1984	Nakornpatom (C)	Pig	Tepsumetanon et al. 1984
Jun. - Aug. 1984	Pisanulok (N)	Pig	Teeraprasert et al. 1984
Jun. - Sep. 1986	Chiengmai (N)	Dairy cattle	Trisanarom et al. 1987
Jun. - Nov. 1986	Supanburi (C)	Pig	Sirivan et al. 1987
Oct. 1989 - Feb. 1990	Petchaboon (N)	Native cattle	Tuntasuvan et al. 1997
Jan. 1992	Patoomthani (C)	Dairy cattle	Indrakamhang et al 1994
Oct. 1994	Chachoengsao (C)	Pig	Sirivan et al. 1994
Dec. 1995 - Mar. 1996	Ayuthaya (C)	Deer	Indrakamhang et al. 1996

C = central region, N = north region, NE = northeast region

In conclusion, surra causes high economic losses in livestock in Thailand because it reduces piglet and calf production, meat and milk production in infected animals and the cost of treatment with antitrypanocidal drugs is high. A single treatment with Berenil to all animals infected with surra would cost about 7.67 million dollars, based on an estimated prevalence in cattle, buffaloes and pigs is about 12.5%, 20% and 4.6% respectively. It is likely that surra will become a more important disease in the future.

REFERENCES

Boonchit, S., Sarataphan, N., Tuntasuvan, D. & Ito, Y. 1996. Seasonal abundance of

Tabanid fly population (Diptera:Tabanidae) at the key farm, in Pathumthani, Thailand. *Abst. 34th Kasetsart Univ. Ann. Conf., Thailand, 30 Jan.-1 Feb., p. 124.*

Boonyawong, T., Chantaraprateep, P. & Muangyai, M. 1975. Surra in horses. *Thai. J. Vet. Med. 5: 665-672.*

Chaichanapunpol, I, Sirirangkamanont, T., Trongwongsa, L. & Suvanwasi, P. 1985. Observations on trypanosomiasis in a native bull. *Kasetsart Vet. J. 6: 7-11.*

Chaichanapunpol, I., Vitoorakool, C., Suvarnvasi, P., Noppakun, W., Panphan, S. & Sakdeechoompol, K. 1987. Study on *Trypanosoma evansi* infection in dairy cattle. *Abst. 10th Ann. Livestock Conf., Department of Livestock Development, Thailand. 19-23 May, p. 9-10.*

Chokesajjawatee, N. 1993. DNA sequence analysis of a specific *Trypanosoma evansi* DNA probe. *MSc. thesis, Mahidol Univ., Thailand.*

Indrakamhang, P., Mohkaew, K. & Roonguthai, P. 1996. Preliminary report on *Trypanosoma* sp. in native Sambar deer and imported Rusa deer raised in a deer farm in Thailand. *Proc. 16th Ann. Livestock Conf., Department of Livestock Development, Thailand. p. 55-67.*

Indrakamhang, P., Neramitmansook, P., Maisuporn, B. & Harintranond, A. 1982. *Trypanosoma evansi* in buffaloes in Pitsanuloke province. *Abst. 20th Kasetsart Univ. Ann. Conf., Thailand. 4-5 Feb., p. 45.*

Ito, Y. 1996. *Prog.Rep.JICA Expert to the Director General, Department of Livestock Development, Thailand, 8 p.*

Kashemsant, A., Pholpark, M., Pholpark, S., Srihakim, S. & Leidl, K. 1989. Epidemiological pattern of *Trypanosoma evansi* in northeast Thailand and control measures. *J. Thai. Vet. Med. Assc. 40: 84-92.*

Lohr, K.F., Pholpark, S., Srikitjakarn, L., Betterman, G. & Staak, C. 1985. *Trypanosoma evansi* infection in buffaloes in Northeast Thailand. 1. Field investigation. *Trop. Anim. Hlth. Prod. 17: 121-125.*

Lohr, K.F., Pholpark, S., Upatum, N., Leidl, K. & Staak, C. 1986. *Trypanosoma evansi* infection, a frequent cause of abortion in buffaloes. *Trop. Anim. Hlth. Prod. 18: 103-108.*

Luckins, A.G. 1977. Detection of antibodies in trypanosome infected cattle by means of amicroplate enzyme-linked immunosorbent assay. *Trop. Anim. Health. Prod. 9: 53-62.*

Mahmoud, M.M & Gray, A.R. 1980. Trypanosomiasis due to *Trypanosoma evansi* (Steel, 1885) Balbiani, 1888. A review of recent research. *Trop. Anim. Hlth. Prod. 12: 35-47.*

Mathias, E. & Muangyai M. 1980. *Trypanosoma evansi* infection in a swamp buffalo calf. *Thai. J. Vet. Med. 10: 47-54.*

NIAH 1996. *Ann. Rep. Natl. Inst. Animal Heal., Department of Livestock Development, Thailand. p. 51.*

Nishikawa, H., Sarataphan, N., Tuntasuvan, D. & Neramitmansuk, P. 1990. Serological survey of trypanosomiasis and babesiosis in cattle and buffaloes in Thailand. *Proc. 7th Cong Federation of Asian Vet. Associ., Thailand (Supplement). 4-7 Nov., p. 9-18.*

Patchimasiri, V., Tochantara, T., Cholayuth, V. & Muangyai, M. 1983. A survey of surra in Thai swamp buffaloes. *Thai J. Vet. Med. 13: 81-91.*

Pholpark, M. 1996. Short Note of the Seminar on Surra in Thailand. *Department of*

Livestock Development, Thailand. 5 p.

Pholpark, S., Pholpark, M., Sarataphan, S., Khunpasi, S. & Taboran, P. 1984. *Trypanosoma evansi* infection in buffaloes in Northeast Thailand. 2. Experimental study. *Abst. 11th Ann.Vet.Conf.the Thai Vet. Med. Associ., Thailand, 4-6 Nov.*

Sananraksat, L. 1949. Surra in Thailand. *J. Thai. Vet. Med. Assc. 1: 22-25.*

Sarataphan, N., Nishikawa, H., Tuntasuvan, D., Sukhapesna, V., Markvichitr, K. & Satjapitak, S. 1989. Effects of natural *Trypanosoma evansi* infection on milk yield of diary cattle in Thailand. *Proc. 1st Symp. on Ruminant Reproduction and Parasitology, Thailand, 27-29 Nov., p. 331-343.*

Sarataphan, N., Sirivan, C., Bunyahotra, R., Mekamol, C., Mepeuch, Y. & Asawamahasakda, C. 1987. Trypanosomiasis in pigs. 2. Study on trypanosomes in Suphanburi sows. *Proc. 6th Ann. Livestock Conf., Department of Livestock Development, Thailand. 18-20 May, p. 84-97.*

Sarataphan, N., Tuntasuvan, D., Sukhapesna, V. & Pramunsinsub, T. 1992. The efficacy of Samorin[R] and Berenil[R] against *Trypanosoma evansi* in experimentally infected rats. *Abst. 19th Ann.Vet.Conf.the Thai Vet. Med. Associ., Thailand, 4-6 Nov. (Supplement)*

Sirivan, C., Pramoolsinsap, T. & Pemayodhin, P. 1994. Effect of diminazene aceturate and isometamidium chloride on the control of *Trypanosoma evansi* in naturally infected sow. *Thai J. Hlth. Resch. 8: 101-109.*

Sirivan, C., Sarataphan, N., Boonyahotra, R., Mekamol, C., Mepuch, Y. & Asawamahasakda, C. 1987. Trypanosomiasis in pig. 1. Occurrence of trypanosomiasis in a pig farm in Suphanburi. *Proc. 6th Ann. Livestock Conf., Department of Livestock Development, Thailand. 18-20 May, p. 84-97.*

Sudarto, M.W., Tabel, H. & Haines, D.M. 1990. Immunohistochemical demonstration of *Trypanosoma evansi* in tissues of experimentally infected rats and a naturally infected water buffaloes (*Bubalus bubalis*). *J. Parasitol. 76: 162-167.*

Sukhapesna, V. 1987. Surra; an important disease in the future. *J. Thai Vet. Pract. Circle 9: 121-128.*

Teeraprasert, E., Chaichanapunpool, I., Trongwongsa, L., Sakdasirisathaporn, A. & Wongkasemchit, S. 1984a. A case report of *Trypanosoma evansi* infection in pigs. *Proc. 11th Ann.Vet.Conf.the Thai Vet. Med. Associ., Thailand, 12-14 Dec., p. 43-64.*

Teeraprasert, E., Trongwongsa, L., Chaichanapunpool, I., Sakdasirisathaporn, A. & Wongkasemchit, S. 1984b. The experimental infection of *T. evansi* in a sow. *Proc. 11th Ann.Vet.Conf.the Thai Vet. Med. Associ., Thailand, 12-14 Dec., p. 43-64.*

Tepsumethanon, V., 1984. Case report on trypanosomiasis. *Proc. 11th Ann.Vet. Conf.t the Thai Vet. Med. Associ., Thailand, 12-14 Dec., p. 43-64.*

Timsad, V., Natephra, S., Saentaweesook, V. & Onwan, N. 1985. Observation of infection of *Trypanosoma evansi* and abortion in swamp buffaloes. *Proc. 4th Ann. Livestock Conf., Department of Livestock Development, Thailand. 3-5 Jul., p. 87-100.*

Trisanarom, A., Markmee, S. & Ped-Ugsorn, C. 1987. *Trypanosoma evansi* infection in Chiengmai dairy cattle. *Proc. 6th Ann. Livestock Confe., Department of Livestock Development, Thailand. 18-19 May, p. 1-12.*

Tuntasuvan, D., Chompoochan, T., Wongpakorn, M. & Mohkaew, K. 1996. Development on serodiagnosis of trypanosomosis in pigs by enzyme linked immunosorbent assay. *J. Thai Vet. Med. Assoc. 47: 45-53.*

Tuntasuvan, D., Sarataphan, N. & Nishikawa, H. 1997. Cerebral trypanosomiasis. *Vet. Parasitol. 73: 357-363.*

Tuntasuvan, D., Sarataphan, N., Siriaroonrat, B. & Sukhapesna, V. 1997. A preliminary survey on surra in Thai elephants (*Elephas maximus*). *Abst. WAAVP 97, South Africa, 10-15 Aug., p. 83.*

Tuntasuvan, D., Sarataphan, N., Sukhapesna, V. & Leelasiri, C. 1992. The efficacy of SamorinR and BerenilR against *Trypanosoma evansi* in naturally infected cattle and buffaloes. *Abst. 19th Ann. Vet. Conf. the Thai Vet. Med. Assoc., Thailand, 4-6 Nov. (Supplement).*

Watanapokasin, Y., Tananyutthawongese, C., Uthaisang, W., Boonchai, N., Chansiri, K., Boonmattit, C. & Sarataphan, N. 1997. Intra-species differentiation of *Trypanosoma evansi* by DNA fingerprinting with arbitrary primers-polymerase chain reaction. *Abst. 23rd Cong. Sci.Technol.Thailand, Thailand. 20-22 Oct., p. 506-507.*

Wuyts, N., Chokesajjawatee, N. & Panyim, S. 1994. A simplified and highly sensitive detection of *Trypanosoma evansi* by DNA amplification. *Southeast Asian J. Trop. Med. Public Health 25: 266-271.*