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Knowledge in Goats in Thailand

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Abstract

The goat population in Thailand is relatively small. However the past 10 years, has seen a marked increase due to an increased demand for goat meat and milk. In the past, the numbers of research publications concerning goats in Thailand were small, especially dairy goats compared with those in other economical livestock such as swine, cattle and poultry. However, the numbers have gradually increased owning to the promotion of goat production by the government. Major research areas have been focused on breeding and genetic improvement, feed and feeding, management, health, diseases and socio-economics. This paper presents background and facilities on goat research in Thailand such as knowledge in terms of breeds and genetic improvement (genetic resources, breed evaluation and breeding and molecular genetics), nutrition, management, diseases and parasites, goat's milk and meat processing. Conclusions and recommendations are also provided.

Keywords: Thai goats, knowledge in goats, research in goats

Introduction

Thailand is located in Southeast Asia with a total area of approximately 513,000 km^2 (198,000 mi^2). The country has a tropical climate dominated by monsoon seasons and characterized by high temperature and humidity. The goat population in 2010 was 380,227 heads (350,851 and 29,426 heads for meat and milk goats, respectively) of which 47.8 % were in southern Thailand. The majority of goats were raised by smallholders in approximately 36,753 households [1]. The Department of Livestock Development (DLD) and a few universities have the facilities for goat research in Thailand. In general, the major factors which affect growth and body composition of goats are genotype or breed, nutrition, age and weight, sex, management and environment. Milk production of dairy goats depends on the breed, parity of dam, number of rearing kids, nutrition, management and environment. In Thailand, studies on goats have been negligible compared with those in other livestock and poultry. However, this paper reviews all available research publications in goats in terms of breeds and genetic improvement, nutrition, management, diseases and parasites, goat's milk and meat processing. Focus areas for goat research by the year 2020 will also be proposed.

Background and facilities for goat research in Thailand

In Thailand, the DLD has major responsibility for providing research facilities for goats and other animals. In addition, some universities such as Kasetsart University, Prince of Songkla University (PSU), Walailak University, Chiang Mai University, Suranaree University of Technology, etc. have established goat research stations. Kasetsart University is the first university to establish goat flock and collected data of goat production. However, little research was done until the establishment of the Thai-Australian Goat Project in 1985. This project, funded by the Australian and Thai governments, was established at the faculty of Natural Resources, PSU [2]. For the next 15 years, this project, which later developed into the Small Ruminant Research

Center, produced more than 60 publications. The body of knowledge gained from this research be continuously benefit for improvement of goat production in Thailand. In the past decade, some universities have established goat flocks and conducted research into goats. However, until now, a new master research project for goats has not been established yet.

Research on breeds and improvement

Genotype plays as an important role in growth and productivity of ruminants. It is well known that crossbreeding indigenous or native goats with European breeds markedly increases the growth rate of kids and milk production. The improved growth of crossbreds may arise initially from hybrid vigor, in the long term, from an increased feed intake and feed conversion efficiency inherited from the European breeds. Information on genetic resources breed evaluation, breeding strategies and molecular genetics of goats in Thailand is provided as follows:

Genetic resources

The domestication of goat species, their movement and distribution across countries have resulted in the evolution of nearly 571 goat breed populations in the world, of which 187 or 33 % are in Europe, 146 or 26 % are in Asia and Pacific regions and 89 or 16 % are in Africa [3]. The enormous diversity of goat genetic resources in the world that have evolved through natural selection, migration, mutation, genetic drift and skillful breeding practices presents opportunities for the genetic improvement of meat and milk goats.

In the 2nd century B.C., goats migrated eastwards through the Khyber Pass into the Indian subcontinent with the expansion of the Aryan empire. Trade between India and Southeast Asia was thriving along the maritime route of Myanmar, Thailand, Malaysia and Indonesia in the 6th century B.C., contributing to the migration goats into those countries from the Indian subcontinent and possibly also from southern China into Southeast Asia [4]. Approximately 10 breeds of goats are present in Thailand: 2 indigenous (Northern Thai Native goat or Bangala and Southern Thai Native, TN goat or Kambing Katjang, KK) and 8 exotic breeds (Anglo-Nubian, AN; Boer, BO; Black Bengal, BB; Jamunapari, Saanen, SA; Alpine, Toggenburg and Laoshan). Goats in Thailand are predominantly used for meat (90 %) production with milk production as a minor industry (10 %) [5].

In northern Thailand, the local Bangala goat has a large and thin body, long pendulous a straight face profile and long hair near their back legs. Body weight at birth, 3, 6 and 9 months of age were found to be 2.2 ± 0.10, 11.88 ± 0.75, 15.63 ± 0.83 and 25.30 ± 1.10 kg, respectively [6]. An indigenous breed in southern Thailand is KK or Pea goats. This goat bears resemblance to several breeds in Malaysia, Philippines and Indonesia. These goats are small in size with short upright ears. Moreover, they possess the natural characteristics of heat and tick tolerance and high fecundity. They could produce approximately 2.0 kids per litter after the first kidding under a harsh environment. This rate was slightly lower than KK does in Malaysia which was reported to be 2.2 kids per litter [7]. Birth weights at 3, 6 and 9 months of age were found to be 1.79 ± 0.33, 8.10 ± 2.13, 12.22 ± 2.63 and 16.43 ± 2.77 kg, respectively [6]. Not only the government sector, but also private sector has established these breed flocks.

Breed evaluation

The evaluation of breeds based on the performance of purebred, crossbred or a combination of both, has provided vital information that demonstrates opportunity for the genetic improvement of morphological characteristics and production performance under specific feeding and management conditions. In Thailand, there are 4 pure meat breeds and 4 pure dairy breeds that were imported from other countries. Anglo-Nubian, BO, BB and Jamunapari goats were meat breeds that were imported from Britain, South Africa, Bangladesh and India, respectively. These breeds were used for crossbreeding scheme in order to increase growth performance in an indigenous breed. However, BO goats are the most popular for improvement of growth and carcass qualities [5].

The most simple growth trait is a “change in size” which can be measured in terms of length, volume or mass including prenatal growth and postnatal growth (pre-weaning and post-weaning growth). Some researchers have studied pre-weaning growth of kids. The birth weight of 25 % AN crossbred kids was higher than that of the TN purebred kids. However, under village environments in southern Thailand, the TN kids

had higher weaning weights and pre-weaning weights than the crossbred. This could partly be due to the fact that the crossbred kids require relatively low milk supply from their native does [8]. Birth characteristics (birth weight, wither height, heart girth, body length and ear length) of TN kids were reported by [9,10]. Body weights at birth, 6 and 12 wk of TN kids were significantly lower than those of AN × TN crossbreds. This result was similar to that of [11] who reported that birth weight, weaning weight and growth rate of TN kids were lower than those of BO purebred and crossbreds among TN × BO × SA. The studies [12,13] reported multiple birth rate and milk yield of 50 % AN × 50 % TN crossbreds were higher than both TN and AN purebreds.

Post-weaning growth of goats has been investigated by some researchers. There was no significant difference in age at puberty among TN, 75 % TN × 25 % AN and 50 % TN × 50 % AN does, among years of kidding and between birth types. There was an interaction effect between breed and year of kidding on age and weight at puberty on growth rate from birth to weaning [14]. Although crossbred goats under village environments in southern Thailand were drenched, during the first four months (no supplementation) all animals lost weight. In the second period (supplementation) all groups, especially for drenched animals gained weight markedly throughout the experiment. This result suggested that nutritional conditions, which may be associated with season or year, should be considered to improve goat production [15]. The body weight of TN and 50 % TN × 50 % AN could be predicted from body length, height at withers or heart girth [16].

In general, investigators have studied growth, body composition and meat quality together. There is some research on growth and body composition but a little on meat processing and storage. The effects of breed and feed scheme on the body composition of TN and crossbred (50 % AN × 50 % TN) weaned kids were found that dressing percentage was increased as feed intake increased but there was no significance. In addition, it was found that the proportion of muscle in the carcass and muscle to bone ratios decreased with increasing of AN breed fraction in the kids [17]. It is suggested that European goats could be introduced into crossbreeding programs for improving carcass and meat to bone ratios. In addition, when compared at the same empty body weight (EBM), 50 % AN × 50 % TN had significantly higher head and blood percentages ($P < 0.05$) and had significantly higher body size and cannon bones ($P < 0.01$) than TN mature does [18]. In-depth study of some groups of several types of crossbred and purebred comparison revealed that there were no differences of body components and dressing percentage among TN, 75 % TN × 25 % AN and 50 % TN × 50 % AN goats. However, TN and 75 % TN × 25 % AN kids had significantly different muscle to bone ratios (4.20 and 4.20 %, respectively) compared with 50 % TN × 50 % AN kids (3.88 %) [19]. Moreover, age, sex and interactions between breed and age at slaughter, breed and sex, age and sex and among breed, age and sex had a significant effect on body composition of TN and AN crossbred goats [20]. Crossbred of 25 % BO × 25 % AN was highest on birth weight and weight at 3 months of age while weight at 6 months of 87.5 % BO × 12.5 % AN was higher than the others at Chaiyaphum Livestock Research Test Station in Thailand [21]. In general, crossbreds tend to have higher births and body weights at various ages than those with TN goats due to a bigger size. It would be suggested that when comparing the characteristics of feed intake, growth rate, and so between breeds, it is necessary to express these as a function of metabolic body weight to enable meaningful comparisons between the different breeds or using the initial weights of the experiment as covariates for the statistical analysis.

In terms of reproductive performances, there have been some studies in TN goats such as fertility and kidding rate in TN goats inseminated with frozen semen [22], pregnancy diagnosis [23], puberty and epididymal sperm reserves in TN bucks [24] and ovulation activity [25]. Comparisons among breeds have also been reported. A comparative study on some reproductive performances of TN and crossbred goats revealed that kidding and multiple birth rates were high (88.3 and 82.4 %, respectively). On average, litter size and multiple birth rates increased with age or parity. However, live-weight at mating appears to be the most important factor affecting the reproductive performances. In practice, these performances in the flock could be

improved by selecting does of heavier live-weight (within breed group and age) for mating [26].

Data on pre-weaning mortality of 1,041 kids born during 1987 - 1992 showed that an average pre-weaning mortality rate of kids was 5.3 %. Most of the mortality occurred at birth (60 %) and between 0 and 7 days (23 %). The 75 % AN crossbred kids had highest mortality rates (14.6 %). The study suggested that mortality of young kids can be decreased though optimal nutrition for the dam, adequate attention during kidding, good sanitation in kidding areas and implementation of preventive veterinary programs [27]. A study of the age and weight at puberty of Thai goats revealed that there was no significant difference in age at puberty among breeds with an average of 161 days. Weight at puberty (17.5 kg) of 50 % AN × 50 % TN crossbreds was significantly higher than 25 % AN × 75 % TN does (16.39 kg) and TN does (16.5 kg) [14].

Since goat milk is less preferred to cow milk among Thai people, the numbers of dairy goat producers in Thailand are much less than those of meat goat producers. Dairy goats in Thailand are mainly crossed between imported dairy breeds and indigenous breeds. The main imported pure breeds of dairy goat in Thailand are SA, Alpine, Toggenburg and Laoshan. Details and description on domestication and history of these dairy goat breeds can be obtained from comprehensive reviews that have been published [28,29]. At present, there are some dairy goat farms that produce goats which have been approved by the Food and Drugs Administration (FDA) in Thailand. Goat's milk yield and its composition depend on breed, nutrition, age and parity of dam, birth type of kids, period of lactation, management, etc.

There have been few research publications in dairy goats in Thailand. Most of them were comparative studies among breed and factors affecting growth traits. For example, sire, dam, litter size, sex, parity and year-season of kidding significantly affect body weight in SA goats [30]. A comparison of average daily gain, age at first mating and age at first kidding between 50 % TN × 50 % SA and 50 % TN × 50 % AN does revealed that these traits were higher for SA crosses than AN crosses [31]. Moreover, [32] who studied in carcass traits reported that crossbred of TN with 50 % dairy breed had higher lean meat percentage but had lower dressing percentage when compared with other breeds. A study of growth performance between TN and SA and crossbred between both breeds at Surat Thani Livestock Research and Breeding Center was reported by [33]. They stated that the SA breed was heavier and grew faster than other groups because of a high feed intake. In contrast, body weight at birth, 3, 6, 9 and 12 months of age among AN purebred, BO purebred, BO × AN crossbred, BO × SA crossbred and several types of BO, AN and SA breed fractions goats were not significantly different but the heart girth of the BO breed tended to be higher than that of the other breed groups [34]. The SA does had higher milk yield in the first and second lactations than TN and their crossbreds [35]. However, comparison between crossbreds of indigenous and milk goat breeds and crossbred of indigenous and meat goat breeds, showed that persistency and milk yield of crossbreds between TN and SA were enhanced when compared with crossbreds between TN and AN goats [36]. This suggests that TN, BO and TN × AN crossbred does produce less milk. Therefore, SA crossbreds are widely used because they produce more milk and had a longer period of lactation. It would be suggested that 25 to 50 % of dairy goats such as SA should be crossed with TN or AN goats to improve milk production because the effect of inadequate milk yield could influence the growth rate of the kids on birth. The milk would be insufficient if the doe had twins or triplets or quadruplets [37].

Goat breeding and molecular genetics

An innovation breeding technology for goat production comes from the application of more recently developed knowledge on quantitative genetics that have achieved success in the cattle, poultry and swine species. These major advances include breed evaluation, crossbreeding strategies, formation of new breeds, selection indices based on phenotypic and genetic parameters by using mixed model methodologies and prediction of estimated breeding values (EBV) for the identification of individuals with potential merit for their genetic improvement. Consequently, accelerated genetic progress has been achieved by selection of breeding replacements from the offspring of parents with outstanding genetic merit and choosing an appropriate mating system. However, the number of studies on breeding and

genetics of goat were limited; there was little evidence to suggest progress in the genetic improvement of meat and milk goats. It was only in a last decade that research results on breeding and genetic of goat production have featured in the scientific literature [38-44].

In the last two decades, goat breeds have been evaluated on the basis of crossbreeding of indigenous breeds with imported breeds in order to combine breed attributes and hybrid vigor to increase performance. Characterization of breed, heterosis and recombination effects are fundamental genetic resources in a crossbreeding system. The optimal use of genetic resources and the comparative efficiency of different crossbreeding systems are determined by variation among breed effects relative to the magnitudes of heterosis and recombination effects. Additive breed and heterosis effects are important for pre-weaning growth traits [38-40]. The AN and SA additive breed effects were 0.41 ± 0.11 and 1.21 ± 0.28 kg for birth weight [39]. Additive and maternal breed effects of BO and SA breeds had significantly positive values ($P < 0.05$) but direct heterosis, maternal heterosis and recombination effects were not significant for pre-weaning growth traits. Therefore, development of genetic progress for growth performance should consider direct genetic effects accounting for maternal genetic effects [40].

An animal model with mixed model equation estimating animal breeding values is widely used to determine (co) variance components with Restricted Maximum Likelihood (REML) methods. These components can estimate genetic parameters such as heritability, genetic and phenotypic correlations between or among traits. These parameters are essential for livestock improvement and breeding programs to maximize production efficiency of animals and high profit for producers and farmers. Heritabilities for litter size, weaned litter size, birth weight, weaning weight and 6 month weight in TN goats at Yala Livestock Research and Breeding Center were found to be 0.17, 0.12, 0.32, 0.52 and 0.33, respectively and genetic correlations among these traits were moderate to high and positive (0.36 to 0.78) [41]. Genetic parameters for birth weight and weaning weight in TN, AN, BO and SA purebreds and crossbreds were reported by [42]. Direct heritabilities for both traits were slightly high (0.44 and 0.51) but maternal heritabilities were low (0.15 and 0.16). The direct-maternal genetic correlations within and between traits were negative. This antagonistic relationship influences the selection response on direct and maternal effects. The direct and maternal genetic correlations between them were high and positive. Moreover, direct heritability on the number of kids born in AN and SA and several types of crossbreds at the same center was 0.04 ± 0.03. Low heritability indicated that does in this herd demonstrated low variation in litter size [43]. Although genetic parameters are necessary for the development of breeding strategies in goats, biology of the animal, cultural strength, the goat population, socio-economic, policy, management and climate change aspects should be considered in the decision-making process because goats are closely associated with the environment and religious rituals.

In the past decade, molecular biology has become popular among researchers. These techniques help to identify genetic variation at specific loci and the association between variation at quantitative trait loci (QTL) and interested traits. They were frequently applied in many livestock species such as dairy and beef cattle, swine and poultry in order to save resources allocated to progeny tests, reduce generation intervals and increase intensity of selection. At present, study of the genetic polymorphisms on candidate genes in Thailand have been the subject of only a few publications because of limited budgets and a small number of goat samples that have a complete pedigree and production information. However, it has been reported that the *BMP15* gene does not significantly affect prolificacy [44] while [45] studied genetic polymorphism of *FecB* gene. This gene is the first major gene to be described that affects ovulation rate and proliferation in sheep. The *FecB* polymorphism was analyzed by Single Strand Conformational polymorphism (SSCP) in TN, BO, AN and SA goats. In this preliminary study, no mutation was detected in these particular goat crossbreeds. Therefore, prolificacy improvement in goats should be based on EBV's for litter size and further investigation of other genetic markers responsible for high prolificacy should be carried out.

Areas of future research including breed improvement in both meat and milk goats suitable for farmers should be undertaken.

Research on nutrition

Goats occupy a most important role in the utilization of agricultural resources in many different climatic areas of the world, especially in Asia and Africa. In general, goats graze local roughages and are supplemented with agricultural by-products. For higher production, some workers have studied feed and feeding of goats in Thailand in terms of feed composition [2], milk production and kid growth [13], supplementation [15,46-50], plane of nutrition [17], energy and protein [50] and digestibility [51,52]. The use of feedstuff and the effects of both quality and quantity on goat production have been also studied.

Good grazing and feeding for goats were reported by [2]. At the goat research station at PSU, stocking rate was relatively high (more than 8 - 12 heads per acre), therefore, some research has been conducted to study ways to improve high production of goats. Productivity of female goats grazing newly established areas with varying levels of supplementary feeding was studied by [46]. It was found that there was no significant difference between nil and 0.25 % body weight (BW) supplementary feeding for growth rate ($g/kg^{0.75}/d$). However, goats fed with 0.75 % BW supplementary feeding had a significantly higher growth rate compared to no and 0.25 % BW supplementary feeding. Supplementary feeding did not significantly affect either kid birth weight or weight gain in the first 6 wk after birth and during this period supplementary feeding had no significant effect on milk production. These findings suggest that under improved pasture which was adequate in both quantity and quality, substantial reproductive performances were achieved from both TN and AN × TN does without concentrate supplementation. Moreover there was no interaction between breed and feeding on reproductive performances (conception rate, % kidding opportunity, % multiple birth rate and post-partum oestrous of does). This result indicates that crossbred does could have similar reproductive performances under improved pasture and concentrate supplementation did not improve these performances [47]. Goats with high supplementation (1.5 % BW/d) had significantly higher growth rates than those with low supplementation (1.0 % BW/d) or no supplementation [48]. Under village environments in southern Thailand, it was found that drenching alone would not result in weight gain unless the nutritional status also improved [49]. Different levels of energy on % kidding rate, % multiple birth and body weight change were found in TN and TN × AN does [13]. Different levels of energy (2,700 and 2,900 kcal/kg ME) and protein in the concentrate (10, 12 and 14 %) did not affect the growth rate of the goats [50]. However, goats fed with a total mixed ration (TMR) with 14 % crude protein (CP) had higher gain and better feed per gain than those of goats fed rations with 10 % of CP [53]. Does supplemented with concentrate contained 2,800 kcal/kg metabolisable energy (ME) produced significantly more milk than those of 2,400 kcal/kg ME and also had higher birth weight and weaning weight [13]. Entire male weaned kids of TN and AN × TN had similar protein and energy requirements for growth, and that these values were similar to those reported for other breeds of goats [51]. Growth, feed utilization and carcass characteristics of TN and crossbred male goats fed with different diets (ground diet, pelleted diet and ground diet plus 50 g/d chaffed Napier grass hay *Penisetum purpureum*) were reported by [52]. There was no significant difference between either types of feeding on growth rate, digestible organic matter intake or digestibility coefficients of nutrients.

Leucaena (*Leucaena leucocephala*) leaves, a tropical legume, result in higher weight gain for goats compared with those fed without tree leaves. It is known that farmers provide leucaena trees to their goats, especially in the central part of Thailand [54]. A study showed that Thapra Stylo (*Stylosanthes guianensis*; CAIT 184) legume is a good source for goat performance. In fact, small farmers allow their goats grazing around and goats consume some kinds of grass, legume, browse tree or weeds for maintenance and production [55]. In addition, it was suggested that palm kernel cake could be supplemented at 30 % in urea-treated panicle as a basal diet for goats [56].

In general, feed cost is a major cost for intensive goat production. Knowledge and research in this area has received more attention than other areas. As mentioned above, studies were conducted on nutrition with other effects such as

breeds, etc. Therefore in the same experiment, scientists could identify more than one effect and/or may be an interaction between those. Although the expense of study on nutrition is relatively high, it is necessary to conduct research on the use of local feedstuff, legumes, browse trees; other agricultural by-products such as from oil palm, pineapple, etc. and stocking rate under different pasture conditions.

Research on management

There was little research on the management of goats in Thailand. A survey research conducted in southern Thailand revealed that goats were raised mainly as a secondary enterprise. Goats were raised in association with agricultural systems such as fishing, rice growing and rubber, oil palm and fruit tree plantation. Tethering was wildly used in all seasons and more than 65 % of owners employed this system. Controlled grazing and free-to-roam systems were mainly used where there was uncultivated grazing land (e.g. fishing villages). A cut-and-carry system was only employed in the rainy season. Goats commonly grazed natural grasses and weeds available. Supplements, mostly in the form of tree leaves, were given only at a low level in the rainy season. Few treatments for physical problems were performed. Bucks were generally raised with does all year round but less than half of producers had breeding bucks [57].

Preliminary information on the productivity of goats under village environments in southern Thailand was reported by [8]. The overall results suggested that the flock productivity could be increased by avoiding kidding in the extremely rainy season. In addition, the value of crossbred animals depends on the farmers' knowledge in management. A survey by [58] found that 279 farmers in Songkla province, southern Thailand could apply some knowledge and government recommendations to practice on their farms. This result suggested that low productivity of goats in terms of fertility, growth and carcass characteristics could be improved by skilled training from experts and academics. Reports from PSU stated that good facilities and management should be established to maintain a healthy goat herd. Therefore, research on goats should be continued. A study of the feasibility of raising goats under improved farm management conditions was conducted. Economic analysis for 2 major types of goat breeding programs (breeding and non-breeding stock) has been conducted. It was found that raising goats as non-breeding stock was more productive than raising them as breeding stock. Other management practices were also compared such as feeding, housing, etc. [59].

Research on management practices for optimum production in terms of reproductive performance, growth, milk yield and its composition, pasture management i.e. co-grazing with other livestock (sheep or cattle) and grazing management under plantation should be carefully planned. At present plantations especially oil palm and rubber tree have increased because of the high return. The development of goat herd management should increase profitability.

Research on diseases and parasites

Diseases in goats including non-infectious and infectious diseases result in a decrease in production and increase production cost. For non-infectious, hypoglycemia and ketosis are metabolic disorders and may play a role in impaired health and production. Infectious diseases in goats caused by bacterial, virus and parasite infection and relate to poor management. In fact, these diseases affect cattle and sheep also. There are a few reports of goat diseases with bacterial infection such as mellioidosis [60] and brucellosis [61]. Foot and mouth disease and caprine arthritis encephalitis are viral diseases that have been reported in Thailand [62]. These diseases are zoonotic infections transmitted form cattle to goats. Infection in animals is thought to occur by inoculation, ingestion or inhalation of environmental pathogens. Thus, the goat herd should be separated from sheep and cattle. Sorting the sick goats and isolating them from the rest of the herd can keep the remaining goat healthy. In general, goats should be closely monitored for disease and have routine health maintenance such as vaccinations. Vaccinations against anthrax, haemorrhagic septicaemia and foot and mouth disease have been carried out by government in order to eradicate these contagious diseases.

The other important diseases that have been observed in Thailand, are helminthiasis including ectoparasites and endoparasites. Mange mites, fleas, ticks and lice are the major ectoparasites infesting goat. To eliminate ectoparasites, pesticides are used either by dipping or high pressure sprays to provide the best results that

effectively kills external parasites on the goats. Insecticides should be used properly and safely because improper use may result in residue in the milk and/or meat. Endoparasites are serious diseases in Thailand lead to economic losses in goats including decreased feed efficiency, increased time to market, decreased carcass value and lethargic. The prevalence of endoparasites in goats that the infected percentage with stomach round worms (*Haemonchus contortus*), coccidian, strongyloides, trichuris and moniezia were 95, 96, 62, 19 and 4 %, respectively [63]. In depth, Choldumrongkul *et al*. [64] studied the prevalence of gastrointestinal nematodes and the effects of the breed group (TN and crossbred), sex and birth type on growth rate and blood constituents of pre-weaning kids. In village environment in southern Thailand, there was no significant difference in growth rate ($g/kg^{0.75}/d$) between TN and crossbred goats during no supplemented grazing. However, during supplementary feeding (64 - 127 days) and throughout period (0 - 127 days) TN goats had significantly lower growth rates than did crossbred goats [65]. The results of this study indicated that drenching alone did not result in increased weight gain except when the nutritional status was also improved. There are several factors which affect the virulence of the endoparasite including rainfall, management, breed and age of the animals. Both heavy rainfall and poor management caused increasing of egg per gram (EPG) of gastrointestinal nematode in goat [49,66]. Thus, it is important for each producer to consider about management system as a whole and find things beside drugs that will help control parasites and create an integrated pest management program. Anthelmintics are still an important part of parasite control. Drugs are used to treat internal parasites such as levamisole, ivermectin, albendazole and fenbendazole. There are a few anthelmintic drugs available which are both safe and efficacious. Some workers found apparent failures in the anthelmintics on controlling gastrointestinal parasites in particular resistance to albendazole and fenbendazole [67]. The problem of drug resistance is steadily increasing. One reason is efficacies of anthelmintics depending on physiological, immunological, ecological and behavioral factors. However, few studies have reported information on the immunological, ecological and behavioral factors related to disease of goats.

The development of genetic is one factor to reduce virulent of endoparasite. There is considerable evidence that part of the variation in host resistance to worm infection is under genetic control in goats. In Thailand, Pralomkarn *et al*. [68] found that TN goats were more resistant to *H. contortus* than AN crossbred goats. Resistance is most likely based on inheritance of genes which play a primary role in expression of host immunity. However, no report showed relative between gene and host immunity in goat in Thailand.

It would be suggested that diseases and parasite epidemiology, genetic to be relatively resistant to parasite infection and the prevention and control of diseases and parasites of goats should be carried out.

Research on goat's milk and meat processing

Milk yield and milk compositions of TN and AN crossbred does grazing tropical pasture were studied. It was found that milk yield of TN crossbred does was lower than AN crossbred does. However, not only the breed effect but also the concentrate supplement influenced the milk yield. However, without supplements, concentration of protein and lactose in the milk from 50 % AN does decreased [69]. The quality of raw goat's milk depends on the breed, nutrition, milking process and storage and sanitation management. A report on the quality of raw goat's milk from 5 farms in lower southern Thailand showed coliform bacteria contamination and antibiotic residue [70]. The result suggested that the producers should seriously consider processing of raw milk. Not only milk production of several dairy goat breeds but also sensory characteristics on milk and its compositions should be studied in order to develop quality and quantity of goat milk.

At present, the demand for goat's milk has increased significantly, therefore goat's milk production should be controlled and qualified by both the FDA and Muslim Halal Authorities.

Moreover, goat's meat is mostly required from Buddhist and Muslim. Therefore, research on the effects of breed and management were firstly concerned for upgrading of goat meat. The influence of breeds and feeding on growth and sensory characteristics of goat meat [71], found that the breed had a significant effect on the sensory quality of goat meat. Meat of AN crossbred goats was more acceptable and had a

greater goaty flavor than those of TN goats. Goats that had a high level fed had a more intense goaty flavor and low acceptability. There were no interaction effects between breed and feeding for growth rate, carcass weight and sensory characteristics.

Although studying of processing and storage of goat meat are necessary for the development of goat meat quality, research on this knowledge in Thailand is very poorly developed. Also, there is a need for research in terms of pre- and post-slaughter and slaughter management, packaging, sensory characteristics and processing.

Conclusions and recommendations

Although there are considerable amounts of research publications in goats in Thailand, further research, both on-station and on-farm are required. The following are suggested areas of research:

1. Research work to improve the economic traits of goats in Thailand should be prioritized. Reliability and accuracy of EBVs must be emphasized. This requires a correct data set and proper models and statistical software. Moreover, producers and/or farmers should be encouraged to cooperate with government agencies on an improvement program. They should keep records on these economic traits as well as on general farm management. These data can be used for monitoring genetic progress.

2. Global warming may result in a decline of genetic diversity and breed distribution in goats. Therefore, the effects of genotype and environment on various traits must be initiated.

3. Utilization of reproductive technologies, molecular markers and strategic crossbreeding should be incorporated into breeding programs. Individual breeders' willingness to become involved in breeding for adaptation and resistance traits in order to reduce the use of alternative control methods (drugs, vaccination, vector control, etc.).

4. There is a need for a multi-disciplinary approach to reduce kid mortality.

5. Utilization of by-products from agriculture, crop and agro-industry residues such as sweet corn waste, pineapple waste, kenaf leaves, cassava leaves and palm leaves could be applied for alternative roughage feed in goat production industries and small farm holders in case of the shortage and higher cost of roughage feed.

6. Thai herbs and natural healing such as *Moringa oleifera* Lam., *Curcuma longa* Linn. and *Azadirachta indica* should be studied and applied for goat production including good nutrition and holistic treatment of illness.

7. Training programs on goat production for field workers and farmers at the village level should be continued. New and appropriate knowledge and technologies should be transferred to the farmers through this activity.

8. Processing of goats milk and goats meat production should be qualified by both the FDA and Muslim Halal Authorities because these products could be exported to Muslim countries.

9. Marketing plans for goat producers should be proposed in order to support marketing on demand.

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