Research article

Effect of Seasons on the Quality of Fresh Semen in Thai Native Chickens: Deang Dok Koon and Pradu Hang Dam

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Abstract This study investigated the impact of seasonal variations on the quality of fresh semen in two Thai Native chicken breeds: Deang Dok Koon (DDK) and Pradu Hang Dam (PD). A 3 × 2 factorial experiment was conducted using a completely randomized design (CRD). The factors considered were season (summer, rainy, and winter) and breed (DDK and PD). Twelve roosters per breed (aged 1 year) and 40 commercial laying hens were housed in open-air conditions. Semen was collected twice a week for 24 weeks (48 total collections). Semen volume, mass movement, sperm progressive motility, sperm concentration, total sperm count, sperm viability, sperm morphology, and fertility were evaluated. No significant interaction was found between season and breed. While the season did not affect mass movement, sperm progressive motility, and total sperm count, it significantly influenced semen volume, sperm concentration, sperm viability, sperm morphology, and fertility. Winter had the highest sperm concentration (4.51×10^9 sperm/mL), followed by summer (4.16×10^9 sperm/mL) and the rainy season (3.82×10^9 sperm/mL). Summer had the lowest sperm viability (93.45%), whereas rainy (95.49%) and winter (95.22%) seasons were similar. Sperm morphology was higher in summer (6.79%) than in the rainy season (5.66%) and winter (5.18%); however, the rainy season and winter were not significantly different. Fertility rates were highest in winter (86.81%) and the rainy season (85.88%), with summer (77.99%) being the lowest. Breed significantly affected mass movement, sperm progressive motility, sperm concentration, and sperm viability, but not fertility. The PD breed showed superior semen quality compared to DDK. Overall, seasonal variations significantly impacted fresh semen quality, with winter providing optimal conditions compared to summer and rainy seasons.

Keywords semen quality, sperm motility, fertility, seasonal variation, Thai native chicken

INTRODUCTION

The Deang Dok Koon (DDK) chicken, a novel synthetic breed developed in Thailand, presents a viable pathway for enhancing employment opportunities in small-scale agricultural sectors. This dual-purpose breed, meticulously selected for meat and egg production, demonstrates exceptional adaptability to free-range environments and exhibits remarkable resilience in high-temperature conditions. With an annual egg output ranging from 220 to 240 eggs per hen (Kunhareang et al., 2023), the DDK breed has garnered significant demand among farmers, necessitating a concerted effort to augment the breeding stock. Artificial insemination (AI) is a highly efficient breeding technique that is contingent on the availability of superior-quality semen. Global warming elevates the Earth's surface and atmospheric temperatures, exacerbating climate variability. This phenomenon can induce significant stress in animals, including poultry. The temperature-humidity index (THI) quantifies heat stress by considering temperature and humidity. Although THI thresholds vary across species, elevated temperatures compromise avian immune function and male reproductive health, affecting semen quality (McDaniel et al., 2008; McDaniel et al., 1996). Thailand's tropical climate, characterized by high temperatures and humidity, presents significant heat stress challenges for poultry. In Thai native PD chickens, a THI of 74 marks the onset of heat stress, which impacts egg production (Loengbudnark et al., 2023). However, the influence of environmental factors on semen quality in Thai native roosters remains uncertain (Sonseeda et al., 2013), potentially due to breed-specific heat tolerance and interannual climatic variations. Given the dearth of research on DDK semen quality concerning environmental conditions, this study investigated the impact of seasonal temperature and humidity variations on semen quality. These findings provide crucial insights for optimizing DDK breeding programs under Thailand's challenging climatic conditions.

OBJECTIVE

This study aimed to investigate the impact of seasonal variations in temperature and relative humidity on the quality of fresh semen from DDK and PD roosters. This study aimed to establish baseline semen quality data for both breeds, with PD serving as a reference standard for the semen quality of native Thai chickens. These findings will inform future efforts to enhance semen quality in both DDK and PD roosters.

METHODOLOGY

Animals and Management

This study was approved by the Institutional Animal Care and Use Committee of Khon Kaen University (Thailand) (approval no. IACUC-KKU-81/66), adhering to the ethical guidelines for animal experimentation established by the National Research Council of Thailand. The study utilized 12 roosters per breed (DDK and PD), aged 52 weeks and weighing 2.5-3 kg. In addition, 40 commercial laying hens were used for AI evaluations.

Semen Collection and Evaluation

Semen was collected from individual roosters twice weekly over a period of 24 weeks, encompassing three distinct seasons: summer (April-May 2023; 8 weeks), rainy (July-August 2023; 8 weeks), and winter (December-January 2023; 8 weeks). A data logger (GSP-6, Elitech, UK) recorded ambient temperature (AT; °C), and relative humidity (RH, %). The THI was subsequently calculated using the equation: $THI = (0.8 \times AT) + (RH / 100) \times (AT - 14.4)] + 46.4$, as developed by Mader and Davis (2013). Fresh semen was evaluated for volume, mass movement, sperm progressive motility, concentration, total sperm count, viability, and morphology according to the methods described by Bakst et al. (1991) and Sonseeda et al. (2013). Artificial insemination (AI) was performed between 4:00 and 5:00 PM. Eggs were collected daily from days 2 to 15 post-AI. Fertility was determined by candling eggs on day 10 of incubation and calculated as the percentage of fertile eggs among the total number of eggs collected (Thananurak et al., 2022).

Statistical Analysis

The experiment employed a 3 × 2 factorial design within a completely randomized design (CRD). Data analysis was performed using analysis of variance (ANOVA) to assess mean differences, implemented using the Statistical Analysis System (SAS) software (SAS Institute, 1996).

RESULTS AND DISCUSSION

Data collected at the experimental site revealed significant seasonal variations in temperature, relative humidity, and THI. Specifically, the average THI during the summer and rainy seasons was 81.41 and 80.34, respectively (Table 1). These values fall within the "emergency" zone for heat stress in laying hens, indicating a severe level of heat stress (Kim et al., 2021). Based on studies examining the impact of THI on egg production and physiological responses in laying hens, four distinct heat stress zones have been defined: no stress (THI < 70), alert (THI 70-75), danger (THI 76-81), and emergency (THI > 81).

Effect of Seasons on Quality of Fresh Semen

An evaluation of fresh semen quality in two breeds revealed significant seasonal variations in several key parameters. Specifically, semen volume, sperm concentration, sperm viability, sperm morphology, and fertility were influenced by the season ($p < 0.05$), as shown in Table 2. In contrast, no seasonal effects were observed for mass movement, sperm progressive motility, or total sperm count ($p > 0.05$). No significant interaction was observed between the breed and season ($p > 0.05$). Elevated ambient temperatures, particularly during the summer and rainy seasons, contribute to elevated THI values, leading to heat stress in livestock. This stress adversely affects the male reproductive function. Studies have demonstrated that heat stress can damage Sertoli cells, resulting in decreased semen volume (Guo et al., 2021), sperm concentration, and increased sperm mortality (Telangana et al., 2021). Consistent with these findings, Elagib et al. (2012) observed a negative correlation between sperm concentration and increasing temperature in White Leghorn chickens in Sudan. Similarly, Adamu et al. (2019) reported a decrease in semen concentration in indigenous Nigerian chickens during the late rainy season, which was characterized by lighter semen color. Furthermore, Pimprasert et al. (2023) observed the highest sperm concentration during winter and the lowest during the rainy season in Thailand.

Table 1 Maximum, minimum and average temperature, relative humidity, and THI for each season at the experimental location

Observations	Maximum	Minimum	Average	SD
Temperature (°C)				
Summer	39.20	22.40	30.28	1.99
Rainy	34.20	23.30	28.02	1.07
Winter	32.80	14.19	24.18	1.89
Relative humidity (%)				
Summer	98.80	39.90	67.77	9.48
Rainy	99.70	57.00	84.73	4.58
Winter	96.70	40.20	74.66	4.44
THI				
Summer	90.50	70.74	81.41	1.78
Rainy	86.78	72.25	80.34	1.25
Winter	84.81	56.06	73.43	3.18

Note: Data were collected from the Integrated Farm of the Department of Animal Science, Faculty of Agriculture, Khon Kaen University.

Heat stress induces oxidative stress, leading to increased lipid peroxidation and the generation of reactive oxygen species (Yongjie, 2020). These reactive species damage cell membranes, increase sperm mortality (Tselutin et al., 1999), and disrupt the spermatogenesis process, increasing abnormal sperm morphology (Fouad et al., 2016). However, these findings contrast with those of Sonseeda et al. (2013), who reported no significant seasonal effects on the semen quality. This discrepancy may be attributed to differences in experimental conditions, including a lower range of average temperatures (20.6-31.2°C) and relative humidity (53.5-82.2%) in the Sonseeda et al. (2013) study compared to the present study (average temperature: 24.18-30.28°C; average relative humidity: 67.77-84.73%). It is also important to consider that, despite being of the same breed (PD), the genetic makeup of these animals may have evolved to prioritize their productivity. High-yielding animals often exhibit reduced fertility (Walsh et al., 2011), which can manifest as a lower semen quality.

This study observed significant seasonal variations in fertility rates, with the lowest fertility rate (77.99%) recorded during the summer season compared to the rainy (85.88%) and winter (86.81%) seasons. The summer season, characterized by the highest THI, induces the greatest heat stress in chickens. While spermatogenesis continues during heat stress, leading to the production of viable sperm, these spermatozoa may exhibit DNA damage (Banks et al., 2005). This damage can compromise sperm integrity and reduce their lifespan within the hen reproductive tract (Wang et al., 2014), thereby limiting the availability of sperm for fertilization (King et al., 2002). These findings align with those of McDaniel et al. (1996), who demonstrated a 42% reduction in fertility in broilers exposed to 32°C compared with those maintained at 21°C. Moreover, McDaniel et al. (1995) observed a reduced ability of sperm from heat-stressed roosters to penetrate the perivitelline layer of the egg. The current study, with an average summer temperature of 30.28°C, further emphasizes the sensitivity of rooster fertility to elevated temperatures. These results suggest that temperatures below 32°C can induce heat stress and adversely affect semen quality in roosters.

Table 2 Effect of seasons and breeds on the quality of fresh semen in DDK and PD.

Factors	Semen volume (ml)	Mass movement (scores)	Sperm progressive motility (%)	Sperm concen-tration ($x10^9$sperm /ml)	Total sperm count ($x10^9$ /ejaculate)	Sperm viability (%)	Sperm morphology (%)	Fertility (%)
Seasons								
Summer	$0.45±0.08^b$	4.24±0.37	59.58±11.04	$4.16±1^{ab}$	1.56±1.56	$93.45±1.91^b$	$6.79±1.57^a$	$77.99±6.78^b$
Rainy	$0.47±0.05^{ab}$	4.34±0.30	60.44±4.64	$3.82±0.56^b$	1.63±1.63	$95.49±1.72^a$	$5.66±1.21^b$	$85.88±3.96^a$
Winter	$0.49±0.05^a$	4.36±0.25	62.69±4.44	$4.51±0.60^a$	1.60±1.60	$95.22±3.20^a$	$5.18±0.60^b$	$86.81±5.89^a$
p-value	0.046	0.37	0.41	0.0064	0.99	0.02	0.001	0.003
Breeds								
DDK	$0.44±0.05^b$	$4.14±0.33^b$	$57.96±7.47^b$	$3.84±1^b$	$1.33±1.33^b$	$93.64±2.84^b$	6.17±1.49	82.19±6.94
PD	$0.50±0.05^a$	$4.48±0.17^a$	$63.85±6.28^a$	$4.48±1^a$	$1.87±1.87^a$	$95.80±1.47^a$	5.58±1.15	84.92±6.59
p-value	0.01	0.01	0.004	0.004	0.001	0.004	0.89	0.13
Seasons *Breeds	0.96	0.32	0.13	0.59	0.44	0.30	0.45	0.71
SEM	0.04	0.09	1.07	0.36	0.48	0.36	0.20	1.05

a, b different superscript letters within columns indicate significant differences (p<0.05).

Effect of Breeds on Quality of Fresh Semen

Breed significantly influenced semen volume, sperm mass movement, sperm progressive motility, sperm concentration, and sperm viability ($p < 0.05$), whereas no significant breed effects were observed on sperm morphology and fertility rate ($p > 0.05$), as shown in Table 2. The effect of breed on semen quality in this study showed that the semen quality of PD was higher than that of DDK. Although DDK has a bloodline of Thai native chickens, being raised in Thailand's environment impacts the semen quality of DDK. The overall quality of DDK is lower than PD, which is consistent with the study of Peters et al. (2008) in Nigeria, who found that seven different breeds, namely Black Nera, White Leghorn, Giriraja, Naked necked, Frizzled, Normal Feathered, and hybrid breed, had different semen volume and sperm concentration. This is due to genetic differences between regions, resulting in different abilities to adapt to the environment of the region.

Tabatabaei et al. (2009) reported that Iranian native chickens had lower sperm concentration and abnormal sperm percentage than Ross-308 but had higher sperm motility and sperm viability than Ross-308. In India, a study was conducted on the semen quality of Naked neck and Bantam chickens and found that the semen quality of the two breeds was different, except for sperm concentration, indicating that the genetic structure of chickens was different, resulting in different semen qualities (Shanmugam et al., 2012). In Thailand, the study by Sonseeda et al. (2013) on Thai native chickens (Lueng hang kaow, Pradoo hang dam, and Chee) reported that the influence of breeds did not significantly affect semen quality. This may be because all three breeds are genetically similar Thai native chickens, resulting in minimal differences in semen quality (Choomee and Wornanthakij, 2017).

In this experiment, breed did not affect the fertility rate ($p > 0.05$), with the average fertility rates of DDK and PD being 82.19 ± 6.94 and 84.92 ± 6.59%, respectively (*Table 2*). Although the semen quality of DDK and PD differed, the fertility rate did not, indicating that the fresh semen quality of DDK was still viable and did not affect fertility rate. Semen quality does not affect the conception rate as long as certain thresholds are met, including a semen volume of not less than 0.2 ml, mass movement of not less than score 2, sperm progressive motility of not less than 60% (Iswati et al., 2018), sperm concentration of not less than 150×10^6 sperm/dose (Kheawkanha et al., 2024), sperm viability of not less than 70% (Iswati et al., 2018), and sperm morphology of not exceeding 20-25% abnormality (Vongpralub, 2016). Therefore, fresh DDK semen is still considered good quality and adaptable to Thailand's environment, and it does not affect fertility rate.

CONCLUSION

A study on the effects of season and breed on the quality of fresh semen in DDK and PD revealed that the summer season resulted in the lowest quality of fresh semen, while the winter season resulted in the highest quality. However, although seasons and breeds affect semen quality, DDK and PD remain within the range of good-quality semen and do not affect the fertility rate, indicating that these chicken breeds can tolerate the environment in Thailand.

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