# 3
# MATERIALS AND METHODS

3.0      **MATERIAL AND METHODS**

3.1      **Study on growth of goats**

3.1.1    Location of study

a)   Kluang

The data for the study was obtained from the goats available at the Institut Haiwan, Kluang. The Institut Haiwan is situated in central Johore and belongs to the Division of Veterinary Services, Malaysia. It was established in 1939 to function as a breeding and multiplication center for livestock. It was also to function as a training center for the staff of the Veterinary Departments and farmers who have interest in livestock. It was to assist the government in the development of livestock programmes for the benefit of the small holders.

This institute is located approximately 90 km north of Johor Bahru, at 103° 19' E longitudes and 2° 01' N latitudes. The climate is characterized by heavy rainfall with an annual average of 2168.28 mm (1981-1998). The wet season comprising of 7 months (March, April, May, September, October, November and December) averaging 155.87 mm per month (1998). The dry season (January, February, March, June, July and August) receive on the average 150.6 mm of rainfall per month (1998). Variation within any one season is much more pronounced and rain usually falls in showers for consecutive days which may be interspersed by period of dry weather of a fortnight or more in length.

The maximum rainfall per month recorded at Kluang

was 551.2 mm in March 1986 and the minimum recorded was only 6.2 mm in February 1987.

The 24 hr mean temperature ranged from 25.5°C to 26.9°C (1981-1998), and have high humidity that ranged from 84.5% to 89.0%. The climatic parameters for Kluang for the year 1998 as a guide are presented below:

| Parameter | Year 1998 | |
| --- | --- | --- |
| | Serdang | Kluang |
| Mean Annual Temperature | 28.3° C | 26.9° C |
| Relative Humidity | 80.3 % | 85.5 % |
| Mean Annual Rainfall | 3154.1 mm | 1859.6 mm |

b)    Serdang

The research station of the Malaysian Agricultural Research and Development Institute (MARDI) is situated about 8 km south of Kuala Lumpur, the capital of Malaysia. It is enshrined in the Agriculture Complex where a number of agencies involved with agriculture related activities are situated. The agencies that are incorporated in this Agriculture Complex" are:

)    Malaysian Agricultural Research and Development Institute (MARDI);

)    Agricultural University Malaysia (UPM) which has been renamed as University Putra Malaysia;

)    State Agricultural Experiment Station;

4)    The Department of Agriculture (Stores);

5)    Food Technology Research Station;

6)    Agriculture Institute Malaysia; and

7)    ASEAN Quarantine Reasearch Station.

MARDI's research station occupies an area of 2000 acres with 16 acres allocated for goat and sheep research. About one acre was reserved for the sheds, milking parlour, dip and site office. The remainder area was planted with Guinea grass for grazing the goats and sheep and some area was planted with Napier as fodder. The grazing area was fenced into 1 acre plots for rotational grazing and some area was reserved for fodder as cut and carry system to feed the lactating and sick animals. The adjoining area of about 32 acres which was reserved as a government quarry was also utilized and planted with Napier and Setaria as fodder for the goats and sheep.

3.1.2    Number of animals

a)    Kluang

The station was established in July 1939. Initially the activities at the station centered on large ruminants. It was only in 1954 that a small herd of Indonesian-type of goats (Etawah) were introduced. The flock was increased by the purchase of 23 local goats in 1955. Later in December 1959 the goat herd was further increased through a gift of 31 goats of the Jamnapari breed by the Indonesia government. By February 1962 the number of breeds of goat were as below:

| Breed | Number |
|---|---|
| Local goats | 132 |
| Jamnapari | 70 |
| Indonesian crossbreds | 139 |
| Total | 341 |

However, by 1st April 1962, the number dropped to 323. The goat breeding programme was partly hampered by the presence of Melliodosis for which sero-agglutination tests were regularly conducted to detect positive cases.

In October 1973, 8 male and 16 female purebred Anglo Nubian goats were imported from Britain and used for mating. Two of the bucks were identified for pure breeding and the remaining six were used for producing crossbred goats. The objective of the farm was to produce purebred and crossbred studs and breeding does for distribution to other states and to the farmers.

On 5th February 1974, another batch of 5 female Anglo Nubian goats were imported from Britain. The animals being in late pregnancy kidded on arrival. However, one of the does died 12 days after arrival due to prolapsed uterus. On 1st January 1975 one female Anglo Nubian was imported from North Carolina State, U.S.A. Further importation took place in April 1976 when 9 male and 15 female Anglo Nubian goats were imported from the United States.

There was no further importation until 4th January 1977 when 17 feral goats were imported from north Australia.

For the present study the birth weight and monthly body weight data of 4956 goats born in 1968 to 1975 was made available of which 151 were Anglo Nubian, 516 were crosses of Anglo Nubian with Katjang, 748 were Jamnapari and 3539 were Jamnapari x Katjang crossbreds. The number of samples for collection of data of different parameters varied such as for birth weight, monthly body weights, weaning weight, adult weight as well as different body measurements. Of the total goats on the farm 3523 were females and the rest were males.

The information was recorded in a number of books and most often there were duplication of the records and some information was missing. However, whatever data that could be salvaged was utilized for the analysis of growth and reproduction. The data that could be obtained was birth weight, weaning weight, monthly body weight to year old and mortality. The data on mortality was extricated from this study as it had been reported elsewhere.

Subsequent to that a trial was conducted at Kluang where a total of 42 Anglo Nubian x Katjang and 72 Jamnapari x Katjang does aged 3 years were identified randomly and mated to a number of sires according to mating plan described below. The mating was repeated 4 times so as to get 4 parturitions in order to gather sufficient number of progeny for statistical analysis. The study initiated in July 1981 as completed in May 1986. Data collected from a total of 324 progenies comprised of 53 AK, 123 JK, 55 S(AK) and 123 S(JK) that survived to year-old were used for analysis. Those that

died before they were year-old were omitted from the study.

    b)    Serdang

        Initially the Katjang goats were selectively purchased from the remote areas as far away as possible from the government veterinary offices so as to assure their purity. Based on the characteristics (see Dictionary of Breeds by I.L. Mason) these animals were directly purchased and kept on the farm. Purebreeding was practiced. To improve the body size Anglo Nubian and Saanen breeds were imported from Australia to cross breed with the Katjang goats. The imported goats succumbed to nutritional and environmental stress (Brachiaria toxicity) which resulted in high mortality in the adult animals. However, those kids born in Serdang and attained one year of age were incorporated into the study.

        The data recorded from 1981 to 1985 on the body weight and survivability of the goats at Serdang was used for initial analysis of their growth performance. Information on only those animals that survived to year-old was used in the analysis. Records on the performance of 31 kids of Katjang (KK), 29 of Saanen x Katjang and 26 of Anglo Nubian x Katjang were made available.

        Subsequent to that twenty-eight F1 does of AK and 8 F1 does of SK breed groups, aged about 2 to 3 years, were identified for the trial at Serdang. They were mated to a number of sires according to plan as stated below. To get sufficient number of observations the does were mated 4 times and the study initiated in January 1981 was completed in

December 1985. As the number of does that kidded varied with
each replicate and due to the high mortality, the number of
progeny or observations also varied for each variable. It may
be noted that it was not possible to get does of exactly the
same age for the study, however, the mean body weight and
mean age of each breed group was very close.

3.1.3     Mating plan

        a)   Kluang

        With the aim of improving the local goats an
upgrading programme was initiated in early 1955. A simple
cross breeding of Jamnapari male to local females was done.
The progeny produced were upgraded to the sire breed to
produce different crossbreds. The crossbreds were then sold
to the farmers to improve their stock. At the same time some
purebred local goats were produced as base for cross
breeding. The Anglo Nubians were also used to produce
crossbred animals.  All matings were random and the mating
plan was as below:

| Anglo Nubian x Katjang | | Jamnapari x Katjang | |
|---|---|---|---|
| A♂ | K♀ | J♂ | K♀ |
| F1 | A♂ x AK♀ | J♂ x JK♀...1/2J+1/2K | |
| F2 | A♂ x AK♀ | J♂ x JK♀...3/4J+1/4K | |
| F3 | A♂ x AK♀ | J♂ x JK♀...7/8J+1/8K | |
| F4 | A♂ x AK♀ | J♂ x JK♀...15/16J+1/16K | |
| F5 | A♂ x AK♀ | J♂ x JK♀...31/32J+1/32K | |

        The present study was confined to the F1 population
i.e. AK and JK breed groups.

In the study with different grades of Jamnapari x Katjang as was done at Kluang, it would have been possible to estimate genetic effects such as additivity, heterosis and recombination loss. However, no attempt was made to determine the heretability, regression and genetic correlations in the present study because the number of records in some of the grades (JK$_u$, JK$_v$ and JK$_w$) were low.

The following plan was adopted for the subsequent breeding of the identified breed groups for this study:

| Mating group | AK♂ x AK♀ | S♂ x AK♀ | JK♂ x JK♀ | S♂ x JK♀ |
|---|---|---|---|---|
| Number of sires | 2 | 2 | 4 | 4 |
| Number of does | 21 | 21 | 36 | 36 |
| Total progeny | 58 | 63 | 161 | 111 |
| Number of progeny survived to year old | 53 | 55 | 123 | 93 |
| Progeny breed group | AK | S(AK) | JK | S(JK) |

Breeds: AK = Anglo Nubian x Katjang
JK = Jamnapari x Katjang
S(AK) = Saanen (Anglo Nubian x Katjang)
S(JK) = Saanen (Jamnapari x Katjang)

The progeny obtained were used to demonstrate the comparative growth potential of the resultant progeny groups when sired by Saanen.

b)  Serdang

Twenty-eight and 68 F1 does of AK and SK breed groups, respectively, aged about 2 to 3 years were also identified for the study. It may be noted that it was not

possible to get does of exactly the same age for the study, however, the mean body weight and mean age of each breeding group was very close.

The does of each breeding group were randomly divided into the different breeding groups and mated to their respective sires as below:

| Mating group | K♂xK♀ | AK♂xAK♀ | AK♂xK♀ | SK♂xSK♀ | SK♂xK♀ |
|---|---|---|---|---|---|
| Number of sires | 2 | 2 | 2 | 4 | 4 |
| Number of does | 13 | 14 | 14 | 34 | 34 |
| Number of progeny | 52 | 45 | 44 | 97 | 91 |
| Number of progeny survived to year old | 44 | 39 | 40 | 89 | 85 |
| Progeny breed group | KK | AK | (AK)K | SK | (SK)K |

Breeds: AK = Anglo Nubian x Katjang
KK = Katjang x Katjang
SK = Saanen x Katjang
(AK)K = (Anglo Nubian x Katjang) x Katjang
(SK)K = (Saanen x Katjang) x Katjang

So as to get sufficient number of observations for meaningful interpretation the does were mated four times so as to get four parturitions and the data collected over the four kiddings to show the trend in respect to birth weight and body growth in the different breed groups.

.1.4    Animal Husbandry

The animal husbandry system at both the stations were as far as possible uniform so as to minimize variation between the stations and the two groups of animals.

### 3.1.4.1 Housing

The goats were housed in a wooden shed raised above the ground at a distance of 150 cm. The floor was of wooden slats of about 5 cm wide with a space of 1.5 cm between each slat to allow the faeces to drop to the ground. The walls were of plank 13 cm wide placed at 13 cm apart to a height of 150 cm from the floor. The roof was of asbestos about 220 cm from the floor. There was ample ventilation in the shed and the shed was kept clean.

### 3.1.4.2 Feeding

All the goats were confined to the sheds and chopped Napier grass (**Pennisetum purperium**) and water were given **ad libitum.** When there was shortage of Napier grass, Bracharia spp, Guinea grass (**Panicum maximum**) and local Paspalum were also fed. A formulatted concentrate ration containing 15% CP (Crude Protein) and 2.26 KCal of ME/kg of feed was also fed at the average rate of 0.25 kg per animal per day as a standard feeding practice.

The composition of the concentrate was as below:

| | |
|---|---|
| Palm kernel cake (expeller) | 25% |
| Palm kernel cake (sol. extr.) | 25% |
| Maize | 20% |
| Tapioca | 15% |
| Rice bran | 11% |
| Urea | 1.5% |
| Dicalcium phosphate | 1% |

| | |
|---|---|
| Common salt | 1% |
| Mineral premix | 0.5% |
| Total | 100% |

As the pens in the shed were on either side with a passage in the centre the feeding troughs were placed along the passage to facilitate feeding of fodder and concentrate, and preventing the animal from getting into the feed trough and soiling the feed. A plastic container containing fresh water was made available on one side of the pen. The container was daily cleaned and filled with fresh drinking water. A mineral block "Rockies" was also tied to one side of the pen as a salt lick.

The kids were reared together with their dams. Weaning was done at 112 days of age and the two sexes reared separately to one year old. A group of male bucks that were identified for the semen studies were, however, reared to two years old.

3.1.4.3    Management

Management practice was uniform for all the animals so as to eliminate variation due to changes in environment and management including feeding.

The lactating does and those which were in a stage of late pregnancy were kept in doors in single pens of 1.2 $m^2$. Wooden boxes were placed in the pen as a standard practice to allow the kids to shelter from draught and trampling.

### 3.1.4.4   Tagging

Individual identification was by using the small "Allflex" ear tag on which were imprinted (grooved) the alphabet and the digits to indicate the breed and identification number. The tag was put on one ear and on the other the identification number was tattooed as a safety measure.   For example:

| A   6045 |
| --- |

where A = Anglo Nubian, the figure 6 = the last digit of the year 1996, and the 045 is the serial number of the animal according to the register which was born in 1996.

### 3.1.4.5   Record keeping

All the information was kept on the Performance Cards and each animal had 2 cards (1 = Health Card; 2 = Performance Card). The cards were kept secured in the office but a book was placed in the shed to record all the related information for each day. The data was stored in the computer and the animals were selected each year. Those that do not meet the criteria were culled and removed from the farm by either sale or slaughter. The animals never reached 10 years on the farm.

### .1.4.6   Health

Routine health management such as deworming, eticking and treatment of sick animals was practiced as a tandard procedure. The male animals were in good health and ad normal testicles.   Animal with any defective testicle

was omitted from the study. The females were also healthy and possessed normal udder. There was no incidence of mastitis on the farm at about that time. However, later a number of does contacted mastitis but they were isolated and treated.

3.1.5     Data collection

3.1.5.1     Age

The kids that were born at the two experimental sites were identified at birth and ear tagged for easy identification. The date of birth was recorded on the same day of birth and the kids that were born in Kluang were reared to two years of age (728 days) whereas those in Serdang were only reared upto 364 days of age.

3.1.5.2     Body weight

Birth weight was recorded on the same day of birth and subsequently every 28 days until the animal reached about two years of age (728 days). Body weight was recorded early morning on empty stomach. The weaning weight was the mean body weight at 112 days of age.

At 9 months of age the best two bucks from each breed group based on highest body weight were identified for sire selection and trained to mount a teaser. The bucks were trained for one month to ejaculate into an artificial vagina, and for the next two months semen was collected and evaluated weekly. The bucks were graded and the best buck in each group was identified for breeding. The non-selected bucks were fattened for sale and slaughter.

The mean body weights of the four breed groups of goat prior to slaughter were recorded. The animals were so identified such that the mean body weights of the different breed groups were as close as possible, and the mean body weight ranged between 17.6 to 19.8 kg. The weight of the AK breed group was found to be slightly lower to JK breed group whereas the body weight of the S(AK) and S(JK) were similar.

### 3.1.5.3  Body measurements

At 12 months of age, before slaughter, the animals were weighed and body measurements (body length, wither height, height at croup, chest width, chest depth, chest girth, barrel girth, and circumference of fore leg) were taken in the four breed groups of the follow up study in Kluang.

In the case of the breed groups in Serdang the body measurements recorded were the body length, height at withers and chest circumference. These three measurements are the most responsive to growth and therefore have been most extensively studied in different breeds by different research workers (Valdez et al., 1982; Bhattacharya et al., 1984; Bose and Basu, 1984; Singh et al., 1987; Islam et al., 1991; Jayaka et al., 1995; Mohammed and Amin, 1996).

The aim of this study was to document changes in body measurements of Katjang and crossbred goats and to find out if correlations exist between body weight and body measurements of wither height, body length and chest girth of the three breed groups (Katjang x Katjang, Anglo Nubian x

Katjang and Saanen x Katjang). A positive correlation would help in estimating body weight of the selected breed groups.

3.1.5.4   Milk production

One week after kidding a 24-hr milk sample was taken weekly at Kluang and Serdang to determine the yield and was analyzed for Butterfat (FAT) using the Babcock Test, Specific gravity (SG) using the lactometer and Solid-not-fat (SNF) using the Ashing technique. The protocol for testing milk was obtained from the Division of Dairying, Department of Primary Industries, Brisbane, Queensland, Australia. These were the only tests available at both the locations at that time. The volume was obtained from the graduated beaker used for milking. The lactation length and lactation yield were also calculated and determined.

The animals were housed in a wooden shed and Guinea grass (**Penicum maximum**) was provided ad libitum in the morning and in the evening. In the afternoon, a formulated concentrate mixture containing 12% protein and 2.26 KCal of ME/kg of feed was fed at the rate of 0.25kg/animal/day. Water and salt lick were also made available in the pen.  The does were in good health and there was no case of mastitis.

From the time of parturition the does were allowed to be suckled by the kids so as to ensure that they get the colostrum. The kids were tagged at one week of age for easy identification. After one week the kids were separated from their dams for a period of 24 hours. The following day, once the does have been milked the kids were joined with their

dams again. The milk collected from the dams was sampled for analysis and the remainder was fed to the kids. In case of shortage of milk, milk replacer was used as supplement. Every kid was fed at least four times a day to make sure they get enough milk for their normal growth and at the same time they were trained to feed from the colony feeder.

The kids were separated and supplemented with milk from other does which were not in the study. However, the left over milk after taking the samples was also fed to the kids. Hand milking was adopted and the same person milked the goats for the duration of study. The udder and teats were washed with clean water before milking and dilute solution of iodine was applied to the teats after milking.

The goats were milked and samples taken until the milk produced was only 50 ml/day, when they were considered to have reached the limit of their lactation.

3.1.5.5    Statistical Analysis of Data

Statistical analysis of the data was done using the IBM 4381 mainframe computer system and utilizing the SAS software package. Statistical Analysis System procedures such as Means (GLM), Correlation, Regression and Graphics (User's Guide: Statistics, 1985) were applied in order to attain simple statistical estimates such as least square means, correlations, regression and graphs.

i     Least Square Means and standard errors

The variables analyzed were birth weight, monthly body weight, weaning weight, 12 month body weight,  and

average daily gain from birth to weaning and from birth to one year old. Least square means ($\pm$SE) where appropriate were presented.

ii a) Analysis of variance (GLM) for body weight.

Considering all the effects were fixed a linear model and its component parts was constructed as follows:

$$Y_{ijklmno} = U + Y_i + C_j + X_k + K_l + S_m + D_n + E_{ijklmno},$$

where $Y_{ijklmno}$ is the observation of $o^{th}$ animal of $k^{th}$ sex of $l^{th}$ type of kidding from $m^{th}$ sire and $n^{th}$ dam and was born in $j^{th}$ season of $i^{th}$ year.

U is the common mean,

$Y_i$ is the effect of $i^{th}$ year,

$C_j$ is the effect of $j^{th}$ season,

$X_k$ is the effect of $k^{th}$ sex,

$K_l$ is the effect of $l^{th}$ type of birth,

$S_m$ is the effect of $m^{th}$ sire,

$D_n$ is the effect of $n^{th}$ dam, and

$E_{ijklmno}$ is the random effect normally distributed with zero mean and a common variance.

All two- and three-factor interactions were considered, but not included in the final model since they were found to be non-significant except in the case of YK and KD at 6 months of age. Hence, all interactions associated with the above main effects are assumed to be negligible and pooled in the random error term.

In order to obtain the sum of squares for each of the main effects a least squares analysis procedure with

073

unequal subclass numbers as outlined by Snedecor and Cochran, 1980 was adopted.

b) The statistical model assumed for birth, weaning and year-old weights in the subsequent trial at Serdang was :

$$Y_{iklm} = U + R_i + X_k + B_l + BX_{kl} + E_{iklm}$$

where $Y_{iklm}$ is the observation of $m^{th}$ animal of $k^{th}$ sex of $l^{th}$ breed group and was born in $i^{th}$ year.

U is the common mean,

$Y_i$ is the effect due to Repetition ($i^{th}$ year),

$X_k$ is the effect of $k^{th}$ Sex,

$B_l$ is the effect of $l^{th}$ Breed group,

$BX_{kl}$ is the interaction between breed group and sex,

$E_{iklm}$ is the effect peculiar to the individual goat and assumed to be randomly distributed.

c) The statistical model assumed for birth, weaning and year old weights for the trial at Kluang was:

$$Y_{ijklmno} = U + Y_i + C_j + X_k + K_l + S_m + D_n + E_{ijklmno}$$

where $Y_{ijklmno}$ is the observation of $o^{th}$ animal of $k^{th}$ sex of $l^{th}$ type of kidding from $m^{th}$ sire and $n^{th}$ dam and was born in $i^{th}$ season of $i^{th}$ year.

U is the common mean,

$Y_i$ is the effect of $i^{th}$ year,

$C_j$ is the effect of $j^{th}$ season,

$X_k$ is the effect of $k^{th}$ sex,

$K_l$ is the effect of $l^{th}$ type of birth,

$S_m$ is the effect of $m^{th}$ sire,

unequal subclass numbers as outlined by Snedecor and Cochran, 1980 was adopted.

b) The statistical model assumed for birth, weaning and year-old weights in the subsequent trial at Serdang was :

$$Y_{iklm} = U + R_i + X_k + B_l + BX_{kl} + E_{iklm}$$

where $Y_{iklm}$ is the observation of $m^{th}$ animal of $k^{th}$ sex of $l^{th}$ breed group and was born in $i^{th}$ year.

U is the common mean,

$Y_i$ is the effect due to Repetition ($i^{th}$ year),

$X_k$ is the effect of $k^{th}$ Sex,

$B_l$ is the effect of $l^{th}$ Breed group,

$BX_{kl}$ is the interaction between breed group and sex,

$E_{iklm}$ is the effect peculiar to the individual goat and assumed to be randomly distributed.

c) The statistical model assumed for birth, weaning and year old weights for the trial at Kluang was:

$$Y_{ijklmno} = U + Y_i + C_j + X_k + K_l + S_m + D_n + E_{ijklmno}$$

where $Y_{ijklmno}$ is the observation of $o^{th}$ animal of $k^{th}$ sex of $l^{th}$ type of kidding from $m^{th}$ sire and $n^{th}$ dam and was born in $j^{th}$ season of $i^{th}$ year.

U is the common mean,

$Y_i$ is the effect of $i^{th}$ year,

$C_j$ is the effect of $j^{th}$ season,

$X_k$ is the effect of $k^{th}$ sex,

$K_l$ is the effect of $l^{th}$ type of birth,

$S_m$ is the effect of $m^{th}$ sire,

$D_n$ is the effect of $n^{th}$ dam,

$P_p$ is the effect of $p^{th}$ progeny group, and

$E_{ijklmnpo}$ is the random effect normally distributed with zero mean and a common variance.

iii      Analysis of variance for milk yield

An analysis of variance was done on milk composition, lactation yield and lactation length using the linear model:

$$Y_{ijklmno} = U + Y_i + C_j + X_k + K_l + S_m + D_n + E_{ijklmno}$$

where $Y_{ijklmno}$ is the observation of $o^{th}$ animal of $k^{th}$ sex of $l^{th}$ type of kidding from $m^{th}$ sire and $n^{th}$ dam and was born in $j^{th}$ season of $i^{th}$ year.

U is the common mean,

$Y_i$ is the effect of $i^{th}$ year,

$C_j$ is the effect of $j^{th}$ season,

$X_k$ is the effect of $k^{th}$ sex,

$K_l$ is the effect of $l^{th}$ type of birth,

$S_m$ is the effect of $m^{th}$ sire,

$D_n$ is the effect of $n^{th}$ dam, and,

$E_{ijklmno}$ is the random error assumed to be normally distributed with zero mean and a common variance.

iv      Correlation

Simple correlation coefficients of birth weight ith subsequent body weights at specific time periods were alculated. Attempts were made to determine the correlation oefficients between body weights and live body measurements s well as carcass measurements.

v    Plotting of Graphs

Growth rates

The Instantaneous Relative Growth Rates of the different progeny groups were computed using the formula given by Brody (1945) which is as below:

$$(IRGR) = \frac{\ln W_2 - \ln W_1}{t_2 - t_1} \times 100 = \dots\dots\dots\%$$

where the numerator is the difference between the natural logarithm of initial body weight ($W_1$) and subsequent body weight ($W_2$) divided by the time interval $t_2 - t_1$, and R is the rate of growth expressed as percentage.

Average Relative Growth Rate was computed by using Minot's modified formula which gives the growth rate as:

$$(ARGR) = \frac{W_2 - W_1}{1/2(t_2 + t_1)} \times 100 = \dots\dots\dots\%$$

The Average Absolute Growth Rate was computed using the formula proposed by Hayes and Armstrong (1943) which is as follows:

$$(AAGR) = \frac{W_2 - W_1}{t_2 - t_1} = \dots\dots\dots gm/day$$

Growth Curves

Adjusted average body weights from birth to 12 months of age at monthly intervals were used to study the growth curves in the different breedgroups. The following functions were fitted to the data:

Linear_____$Y = a + bx$

Exponential_____$Y = a^{kt}$

Quadratic_____$Y = a + bx + cx^2$

Age-weight relationships were studied using linear, quadratic and exponential functions on average monthly body weight of the four breedgroups at Kluang.