The Water Buffalo

DEPARTMENT OF STATE
AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D.C. 20523

A COMPILATION OF AVAILABLE DATA

on

THE WATER BUFFALO

by

Bradford Knapp, Livestock Specialist
International Cooperation Administration

June 1957
Reprinted June 1967

DEPARTMENT OF STATE
AGENCY FOR INTERNATIONAL DEVELOPMENT
Washington, D. C. 20523

TABLE OF CONTENTS

	Page
Chapter I Introduction	3
Chapter II Physiology of Reproduction in Water Buffalo	6
1. In the Male Water Buffalo	6
2. In the Female Water Buffalo	7
Chapter III Factors of Reproduction in the Water Buffalo	13
1. Age at Puberty in the Buffalo Cow	13
2. Age at First Calving	14
3. Calving Interval	16
4. Sex Ratio of Buffalo Calves	17
5. Twinning Rate in Buffaloes	17
Chapter IV Anatomy, Blood Analyses, and Body Measurements	18
1. The Skeleton	18
2. Measurements of Live Animals	18
3. Alimentary Tract	18
4. Composition of Blood	19
Chapter V Milk and Butter-Fat Production	20
1. Milk Production	20
2. Composition of Buffalo Milk	25
3. Butter-fat Production	28
Chapter VI Longevity and Mortality Rate	29
1. Longevity and Mortality Rate	29
2. Generation Interval	31
Chapter VII Growth of Water Buffaloes	32
1. Birth Weight	32
2. Birth to Two Years of Age	33
Chapter VIII Meat Production of the Water Buffalo	33
1. Veal Production	33
2. Meat Production	35
Chapter IX Disease Resistance of the Water Buffalo	36
Chapter X Skin Structure of Water Buffalo	37
Chapter XI Heat Tolerance Tests of Water Buffalo	40
Chapter XII Economic Evaluation	42
Chapter XIII Review of Present Situation	44
Bibliography	48

Chapter I Introduction

The true buffalo, as contrasted from the American Bison, is indigenous to Asia and Africa. All of the several species of "Bovinae" are usually classified in the genus "Bos" of which Bos bubalis the Asian buffalo is but a species. MacGregor (53) proposes that since crosses between the water buffalo and domestic cattle are impossible that the water buffalo should be a seperate genus from that of domestic cattle. However, the usual classification of water buffalo is "Bos bubalis". The African relative is usually classified as "Bos caffer".

The domesticated water buffalo (Bos bubalis) has been known in the Far East since before written history and has emigrated from its original area, probably Eastern India and Burma, to all of the countries in tropical Asia, and the Near East, to some countries in Southern Europe, and to two countries in the Americas. Table I gives a complete list of all countries where the water buffalo is found and estimates of numbers of water buffalo where data were obtainable. It is estimated that there are a total of 80 million head of water buffalo in the World out of a total cattle population of 250 million head. The human population in these countries total 750 million people out of which 200 to 250 million people are dependent on the water buffalo for milk and milk products, meat, and work. Two countries in the Americas, Surinam (Dutch Guiana) and Trinidad, report that limited numbers have been imported.

There are no records to show when the domestication of the water buffaloes began or their origin. It is believed that the present day domestic water buffalo originated from the wild water buffalo of the Indian jungles (Bos arni). The head shape of some of the Indian buffaloes, particularly the Jaffarbadi breed, is similar

Table I. Population, number of cattle and water buffalo by countries (Numbers in thousands).

Country	Human Population	All Cattle	Water Buffalo
Borneo	334	-	62
Brunei	46	-	11
Burma	19,434	6,045	843
Cambodia	4,074	-	310
Ceylon	8,384	1,975	8,384
China	601,912	28,800	12,470*
Egypt	23,240	2,888	1,300*
Greece	8,050	1,040	76*
Guam	59	10*	1*
India	377,000	203,700*	44,800*
Indonesia	82,450	8,838	2,911
Iran	21,146	5,000	194*
Iraq	5,200	1,450*	450*
Italy	48,001	9,250	12
Lebanon	1,425	-	10
Malaya	5,750	527	243
Pakistan	75,842	29,100	5,600*
Philippines	21,849	3,988	2,862
Sarawak	605	-	3
Syria	3,906	-	4
Taiwan	9,000	395	318
Thailand	20,300	7,629	4,500
Turkey	24,112	12,000	1,013
Vietnam	22,614	-	201
Yugoslavia	17,555	5,283	71

Note: The following countries have reported water buffalo but the number of animals is not known: Albania, Australia, Afghanistan, Bulgaria, Hungary, Laos, Rumania, Surinam, and Trinidad.

* Data from respective countries, other data from USDA statistics.

The water buffalo produces a milk that in spite of its high fat content is white in color. Butter from water buffalo cream is also white and appears much like white oleomargarine. The white color is due to lack of carotine although it is high in Vitamin A. The butter-fat is usually converted to a clarified cooking oil known as "ghee" in India and "semna" in the Arab world. Ghee made from water buffalo butter-fat is said to keep better and have a better flavor than that from cows milk. In Egypt, the bull calves are usually slaughtered as vealers because of the high value of milk and because the grown male is usually vicious in temperament. Castrated males, however, are quite docile but castration is seldom practiced in Egypt. Meat from older cows tends to be coarse in texture and touch to eat. The hides from grown cattle are thick and, when properly tanned, make excellent leather.

As a work animal, the water buffalo has some outstanding traits. Its large feet make possible work in the rice paddies and fields where smaller footed cattle could not work as well. Their gait is slow but the water buffalo is powerful and on farm roads it can move loads of one ton or more. During extreme heat of the summer, the water buffalo cannot work during the heat of the day because of its poor temperature regulating mechanism. Aside from this, it is considered a fine draft animal.

In general, although the water buffalo lacks much to be desired as an economical producer of milk or meat, it has been and will be an important part of the agricultural economy of the Near and Far East. The water buffalo is not likely to be replaced by other species in the foreseeable future.

Until the past ten years little attention has been paid to the water buffalo by research organizations. This is partly due to limited research facilities in these areas as much as lack of interest on the part of the animal husbandman. It is the purpose of this report to assemble as much information as possible on the water buffalo.

Chapter II. Physiology of Reproduction in the Water Buffalo.

1. In the Male Water Buffalo, MacGregor (53) suggests there are two types of water buffalo, a swamp type and a river type. The male sexual glands vary with the type. In the river type, the penis hangs six inches to a foot below the abdomen in a pendulous sheath similar to many of the Zebu cattle. The scrotum of the river type has a distinct neck and is also pendulous. In the swamp type, the penis is held close to the abdomen and the scrotum has no neck and is held close to the body. There is no tuft of hair on either type at the preputial orifice. In other respects, the male genetalia are similar to that of the domestic bull.

Normal semen characteristics of water buffalo males has been reported by Shukla and Battacharya (74), Prabhu and Battacharya (63) and Hafez and Darwish (44). The average results are as follows:

	Shukla and Battacharya	Prabhu and Battacharya 1/	Hafez and Darwish 2/
Volume ml	1.8	2.33	3.31
Concentration M/ml	631	1046	645
Total sperm	1036	2422	2134
Motility	3 to 4	3.07	7.25
% live sperm	-	77.36	80.1
% abnormal sperm	7.7	5.14	21.1
pH	6.27	6.79	-

1/ Averages of first ejaculates.

2/ Initial values of bulls under study.

There was considerable variation in the samples taken by the several authors. Concentration and total sperm per ejaculate seem to be the most variable. This should be expected in view of varying conditions of climate, environment, and collection technique.

Prabhu and Battacharya (63) reported on the semen characteristics of first and second ejaculates collected as rapidly as possible from water buffalo males. The average volume in the first ejaculate was higher than that of the second ejaculate, 2.33 and 2.044 cc respectively. The average motility score was 3.07 for the first and 3.32 for the second ejaculate, indicating that motility was slightly better in the second ejaculate. The average sperm concentration was higher in the first than in the second, 1046 to 971 million per cc respectively. The first ejaculates were higher in percent of abnormal sperm, percent of dead sperm, percent of weakly motile sperm, and lower in percent of actively motile sperm and total motile sperm than the second

ejaculate. The pH was lower in the first ejaculate than in the second. The average reaction time was faster to obtain the first ejaculate than that of the second, 33.13 seconds and 38.48 seconds respectively. In most of the characteristics studied the second ejaculate was superior to the first.

Hafez and Darwish (44) collected four successive semen samples at intervals of 24, 12, 8, and 2 hours. Four bulls were used and during the entire experiment, each bull was subjected to each one of the four time intervals. Ten days elapsed between each treatment. Storage studies were also a part of the experiment.

The rate of decline in semen quality varied with the interval of collection. The semen character least affected by successive ejaculation was the percent of live sperm and the percent of abnormal sperm was the most affected by successive ejaculation. Volume and concentration did not vary significantly in the four interval groups. Storage studies indicated that interval of collection materially affected the storage properties of the semen. Motility and percent abnormal sperm were most affected by storage.

In the Egyptian male buffaloes, Hafez (33) reports that buffalo bulls acted similar to that of domestic cattle bulls at the time of sexual intercourse. Fierceness was observed only at the time of ejaculation. Time between two successive copulations ranged from 30 seconds to 20 minutes. Several of the buffalo bulls showed a preference to particular females. Heavy rainfall and severe hot climate depressed sexual desire in the bulls whereas sprinkling with water stimulated sexual action.

2. In the Female Water Buffalo - Female Reproductive Glands - All of the cattle family (Genus Bos) have the cotyledon type of placenta. The domestic cow (Bos taurus) have from 70 to 140 cotyledons arranged in rows. Hafez (37) made a study of the female genitalia of 52 pregnant and 24 non-pregnant water buffaloes. Observations on the non-pregnant uteri included the phase of the oestrous cycle as determined by examination of the ovaries. The pregnant genitalia represented five stages of pregnancy from very recent to mid-pregnancy. The stage of pregnancy was estimated from the weight and length of the embryo, though the latter gave the more accurate estimate of age.

In the non-pregnant uteri, the inner lining (ENDOMETRIUM) was divided into two regions, the small swellings or eminances that form into cotyledons upon pregnancy (CARUNCLES), and the area of the lining between these swellings (INTERCARUNCULAR AREA). These caruncles are, in the non-pregnant uterus, local thickenings of the under connective tissue layer of the uterus. These areas are well supplied with blood with many small blood vessels. The caruncles varied in size according to the stage of the oestrous cycle, being larger during oestrous and almost indistinguishable during mid-oestrous. The number of caruncles varied from 90 to 140 total for both horns. Three, four, and five rows were observed in one uterus. There was no significant difference in the number in the right or left horns.

During pregnancy, there is considerable increase in the blood supply to the uterus and this is observed in both the cotyledons and intercotyledonary area. In the very earliest stages of pregnancy, there was only loose attachment of the embryonic membranes to the maternal cotyledons. In the second stage of pregnancy, the villi appeared on the surface of the chorionic membrane. During the third stage of

pregnancy, the foetal cotyledons were visibly arranged in rows and had surfaces which fitted into the concavities of the maternal cotyledons. In stage 4 of pregnancy there was a fair degree of adherance between the chorionic villi and the maternal cotyledon. As pregnancy advanced, there was an increase in the size and number of blood capillaries. In stages 5 and 6, seperation of maternal and foetal membranes was difficult. The foetal membranes reached their maximum length very early in pregnancy.

In the gravid horn, the average number of cotyledons varied from 31 in early stages to 89 in the late stages whereas in the non-gravid horn the average number ranged from 11 to 58. The largest number observed was 110 in the gravid horn and 107 in the non-gravid. The number of cotyledons in the gravid horn was larger than in the non-gravid. The diameter of the cotyledons increased as pregnancy advanced from 1.2 cm to 6.1 cm in the gravid horn and from 0.2 cm to 3.1 cm in the non-gravid horn. There was a trend of decrease in cotyledon number after mid-pregnancy. These changes observed are similar to those observed in domestic cattle during pregnancy.

Hafez (43) studied the foctal-maternal attachments from 83 pregnant buffalo cows. No ova imigration from one horn to the other was observed. The number of cotyledons varied from 42 to 147. The number as well as the diameter and height of cotyledon varied with the stage of pregnancy and position in the uterus. The maximum diameter of cotyledon observed was 13 cm.

3. Length of Oestrous Cycle - Hafez (34) made a study of the oestrous cycle on 31 water buffalo cows. The onset of oestrous took place between 6 p.m. and 6 a.m. in 84 percent of the oestrous periods studied. The average duration and range of duration in days and hours of each phase of the oestrous cycle were as follows:

	Range	Average
Pro-oestrous	6 hrs. to 2 days 22 hrs.	21.2 hrs.
Oestrous	12 hrs. to 2 days 12 hrs.	1 day 4 hrs.
Metoestrous	6 hrs. to 2 days 12 hrs.	19 hrs.
Dioestrous	7 days 22 hrs. to 24 days 10 hrs.	17 days 10 hrs.

For the entire oestrous cycle the average duration was 20 days, 9.6 hours, with a range of from 8 days 6 hours to 24 days 10 hours. This compares favorably with reports from other countries and another report by Hafez.

Ocampo (58) reports that oestrous is much more marked in the Philippines buffalo cows than in the Indian buffalo cows. The only means of detecting oestrous in Indian buffaloes was by putting the bulls with the cows in which case those cows in heat allowed the bulls to serve them. In the Philippine buffalo, oestrous lasted one day or less but in two cases oestrous lasted four and five days in one cow. In the Indian buffalo, oestrous always lasted less than one day.

Ocampo (58) reports the duration of oestrous cycle in Philippine buffalo cows as 33.6 days with a range of 27 to 46 days. In Indian buffalo cows, the oestrous cycle was 37.1 days and a range of 34 to 39 days. Crossbred cows from Philippine

and Indian averaged 31.3 days with a range of 20 to 39 days. Asdell (3) reports the average oestrous cycle as 3 weeks but is much more variable than the domestic cow. He also reports that Chinese water buffalo cows have oestrous cycles of 28 to 30 days.

Silent heat, the presence of ovulation without outward display of heat, occurred in 36 percent of the oestrous cycles observed. (Hafez) There was considerable individual variation in the frequency of silent heat. Hafez in another study noted 2 out of 5 heat periods as silent heat periods. Silent heat is probably one of the greatest unsolved problems in the reproduction of the buffalo. Some of these silent heat periods may be periods of very short duration and not recognized by the observer. Nonetheless, these short periods would be missed by the farmer and silent heat probably is responsible for much of the low fertility observed in the buffalo. It has been suggested that silent heat may be due either to failure of the secreted oestrognes to reach the threshold required for outward display of heat or to the intervention of a nervous block due to secretion of oestrogen in excess of the critical level. The former seems more likely to be the case, however, in view of observations by El Attar (22), other environmental factors may also play an important part in the frequency of silent heat. This problem is in need of further research.

Postpartum oestrous, that is oestrous following calving, occurred on an average of 43.8 days following parturition. The range was from 16 to 76 days. The interval from calving to next conception average 81.4 days, but the range was from 22 to 282 days. There was a positive relationship between the number of silent heat periods observed in the individuals and the number of services required per conception. The average in this study of 81.4 days between calving and postpartum conception hardly justifies the 500 to 550 day average calving interval observed in the buffalo cow.

Phillips (62) suggests that the water buffalo cow shows a strong tendency to be a seasonal breeder rather than breeding during the entire year as to cattle. He states that calving in most countries takes place between August and October. Hafez (34) in his study on puberty in the buffalo cow observed varying periods of anestrous with considerable variation between individuals, some going from February to September without displaying oestrous. The frequency of anestrous periods is not known but should be studied.

4. Length of Gestation Period - Many factors influence the length of gestation period in the domestic cow. Some of the more important are: the sex of the calf, the individual physiology of the cow, the breed of the cow, the sire of the calf, season of calving, and the genetics of the calf. Some of the influences have been studied on the water buffalo.

The average gestation period has been reported by many research men. Sidky (76) reports 10½ months, Ragab and Asker (65) report 316.7 days, Hafez (31) reports 316.4 days, and Ghanem et al. (26) reports 316.4 days. The figure of 316 days can be taken as a reasonably good estimate with a standard deviation of approximately 8 days.

Rabab and Asker (65) made a study of the factors influencing length of gestation period in the water buffalo. The average gestation period for bull calves was found to be 317.5 days and for heifer calves 315.8 days, but Ghanem et al. (22) report almost exactly opposite lengths. The difference of 1.7 days was statistically significant. The significant difference reported by Ragab and Asker (65) between the gestation periods of the two sexes is consistent with the usual results found in the domestic cow.

Ragab and Asker (65) observed no significant effect of calving sequence or age of dam on the length of gestation period. However, Ghanem et al. (22) found that 8 percent of the variation in gestation period was due to age of dam. Ragab and Asker (65) report a slight tendency for first calves to be carried longer than later calves but Ghanem et al. (86) report that older cows carried their calves 319 days while the younger cows carried their calves only 316 days. The writer (52) found that in domestic cattle there was no trend in length of gestation period due to age of cow. The contradictory evidence of Ghanem et al. (26) may be due to unusual circumstances of management or selection within the population they studied.

Month of calving had a significant effect on the length of gestation period in the water buffalo. However, the data are limited due to the general practice of having all water buffalo cows calve during the Fall, Winter and Spring months. As a result, 96 percent of the buffaloes calved between August and March. The general tendency was for the gestation period to increase in length during the Fall months. Ghanem et al. (26) report significant seasonal effects on length of gestation. The writer (56) found in domestic cattle that the gestation period during the hot summer months is shorter than at other seasons, and that the longest gestation periods may be expected when cows calve during the Fall months, September through November. This similar condition appears to exist in the water buffalo.

The genetic constitution of the calf in utero has a pronounced effect on the duration of gestation. This genetic effect has been demonstrated many times in domestic cattle. A similar situation also seems to exist in the water buffalo. It was found that the variation between sire groups was highly significant although only 6 sires were represented. Ghanem et al. (23) report that sire effects account for 6% of the variation in birth weight.

The breed of the cow, her genetics and physiology has a most important influence on the duration of gestation in domestic cattle. In Egyptian water buffalo, these cow influences are more pronounced than those observed in cattle. This is shown by the correlation in length of gestation from the same animal. Ragab and Asker (65) report a correlation of .50 where in the Egyptian cows only a correlation of .34. The writer (56) reported in Shorthorns a correlation of .20. Breed differences apparently exist for various average gestation periods, have been reported of 300 days for some Indian water buffaloes, and later 310 for another group. The breed variations are at present unknown.

Gestation period is variously reported as 305 days to as high as 332 days. (Asdell, 3), however, the majority show from 310 to 320 days. Ocampo (58) reports 316.2 days, Villegas assumes 324 days, and Hafez (28) reports 316.8 days. Maymone (54) reports 311 days as the average in Italy. In general, 316 days may be accepted as the average gestation period in water buffalo.

Post-partum oestrous is variously reported as 35 to about 100 days. Ocampo (58) reports 35 days for carabao, 49.6 days for Indian buffalo, and 44 days for the crossbred carabao Indian. Asdell (3) suggests two types of buffalo, the swamp type that experiences postpartum heat 65 days after parturition and the river type with 42 days. Hafez (28) reports an average of 35 days in Egyptian buffalo.

5. Hormone Studies - El Attar (22) reported that the estrognes in female water buffalo urine during pregnancy are extremely low but he suggests the possibility that the estrognes may be excreted in the feces instead of in the urine. He found that at all stages of gestation the estrogen content of buffalo urine was too low to have any commercial value. It is possible, however, that the determination of estrogens in the urine of the buffalo may be of some value in determining causes of certain reproductive failures. It has been shown that foetal mortality is associated with luteal deficiency. The buffalo has been reported to have a high incidence of foetal mortality.

Hafez (32) reports a study on the use of gonadtrophin hormones to induce ovulation in the water buffalo cow. Two groups of cows were treated: Group 1 consisted of nine cows showing complete anoestrous condition; and group 2 consisted of 10 buffalo cows that had calved and had shown two post-partum oestrous cycles before hormone treatment. Group 1 was injected with 1200, 1800, 2400 I.U. of pregnant mare serum (PMS) the dose divided into 3 equal portions and given on three consecutive days. Group 2 was injected with the same quantity of PMS but the dose was divided into two equal portions and injected on two successive days approximately 5 days prior to expected oestrous.

The results show that all anoestrous cows (group 1) experienced oestrous from 4 to 6 days after the third injection and when mated required but one service for conception. Group 2 cows experienced heat within 2 days of their expected time of oestrous and required 1.1 services per conception. It was concluded that subcutaneous injection of PMS was effective in inducing ovulation in anoestrous buffalo cows but was of no value in inducing multiple pregnancy (twins) in sexually active cows. These results are important as a means of overcoming some of the breeding difficulties in water buffalo cows.

percent more cycles. Seven cows remained anoestrous for periods ranging from 3 to 12 months. Foetal mortality was observed in 3 out of 33 cows. Embryonic mortality was associated with smaller corpus lutea and a shorter cervix.

Anatomic infertility was caused by cystic ovaries, cystic corpus lutea, or incomplete development of one or both ovaries, congenital abnormalities such as rudimentary genitalia, blocked fallopian tubes, single horned uteri, lack of opening (atresia) in one or both horns, and double uterus. Cerviciti was common and in a number of cases the lining of the uterus (ENDOMETRIUM) was inflamed.

Hafez concludes that repeat breeding is not a permanent characteristic of the water buffalo cow but that the causes of silent heat are one of the unsolved problems in fertility of the water buffalo cow.

Hafez, (29, 30) in two studies on conception rate of buffalo cows reports that virgin heifers have a higher breeding efficiency than that of cows previously bred. Heifers produced 91.67 percent calves as against 83.05 percent for cows. However only 47.92 percent of the virgin heifers required only one service for conception as against 57.76 percent of the cows requiring one service, nearly twice as many virgin heifers conceived with two services. (35.52 percent) than that of the cows (17.82 percent). The percent requiring three or more services was 8.33 and 7.47 for virgin heifers and cows, respectively. Three groups of cows were distinguishable: Group 1 conceived yearly and always required one service, group 2 were consistent repeat breeders and usually calved every other year, and group 3 were not consistent in breeding behavior requiring one service some years and several services in other years. It is interesting to note that all high milk producing cows belonged to group 3.

The oestral cycles were grouped into 5 classes based on length of cycle. These were: short, single, double, triple, and very long cycles. Normal single cycles occurred in 40.43 percent of the observed cycles and averaged 21.14 days in length. Double cycles occured in 30 percent of the cycles and averaged 43.94 days in length. Triple cycles occurred in 11 percent of the cycles and average 69.28 days in length. Oestrous cycles following silent heat periods tended to be longer than normal 21 days. Very long periods averaged 95.40 days and occurred in 11 percent of the time.

7. Foetal Mortality - Hafez (35) reports 7 cases of foetal atrophy in 50 pregnant cows slaughtered for study. He classifies the cases of foetal atrophy into 4 types. Type 1 are those that occur in very earliest pregnancy and was the most common of the four types. Type 2 are those also of early pregnancy but the foetus and foetal membranes are easily defined. Type 3 occurs during mid-pregnancy and Type 4 occurs during later pregnancy. He found that in cases of foetal atrophy, the diameter of the corpus luteum of pregnancy was less than that of a healthy pregnancy. This suggests that a deficiency in the hormone production to meet normal requirements of physiological function may be the cause of the death of the foetus and the atrophy following. Much more research is needed on this subject:

8. Mating Behavior in the Water Buffalo Female - The breeding habits and mating behavior of water buffalo has been observed by several writers (Hafez 28, Hafez 33, Ocamp 58). There seems to be considerable variation between countries and types or breeds of buffalo in their breeding habits and behavior.

In the Egyptian gamousa female (Hafez 28) as active heat approaches, the females tend to become restless, roam about the paddock, or at other times stand quietly with her head held in the air. Changes in feeding habits and sometimes loss in milk flow may accompany heat. Other cows may sniff the cow in heat but no female heat was observed sniffing the other cows. Homosexual behavior (mounting or being mounted by other cows) was never observed though this is common among domestic cattle. Ocampo (58) reports that Indian buffalo cows also do not display this homosexual behavior but that Philippine carabao females frequently do so. Hafez (33) reports that 84 percent of the oestrous periods started between 6 PM and 6 AM. Certain cows also displayed a pre-mounting grunt even when no bull was present. Some cows allowed mating with great difficulty.

Chapter III Factors of Reproduction in the Water Buffalo

Fertility in all farm animals is of utmost important in economic production of milk, meat, wool, or other livestock products. In dairy animals, since milk production is one of the functions of reproduction, fertility rate is critical. The water buffalo is generally considered to be a very irregular breeder but the frequency of its irregularity and the causes are important to be studied, known, and understood by the breeder or farmer. Many factors enter into total fertility rate. These are: age at puberty, oestrous cycle, length of gestation period, age at first calving, calving interval, generation interval, and lastly the effect of heredity on all of these characteristics. The water buffalo cow resembles the cow in its reproductive pattern, such as length of oestrous cycle and duration of oestrous, but has a longer gestation period than the domestic cow. A study of each factor influencing fertility is necessary.

1. Age at puberty in the buffalo cow:

The age of puberty in all animals is dependent on a number of factors, the most important being (1) genetic differences between species, breeds, and individuals within the same breed; (2) sex of the animal; and (3) the level of nutrition and other environmental conditions under which the animal was raised. The water buffalo is generally considered to be very late in reaching puberty when compared with the domestic cow.

Hafez (40) made a study of 35 buffalo females. The females were all born in December and January and all reared on skimmed and whole milk, plus a mixture of concentrates after weaning. At 8 months of age regular observations were made on the onset of heat and each heat period confirmed by rectal palpation of the ovaries. Many silent heat periods were observed, also confirmed by palpation.

At the first oestrous observed, the symptoms of heat were weak and the females were not attracted to the male. The average age at first oestrous was 405.5 days, though the range was from 347 to 684 days. The majority of the cows experienced first oestrous in the months from January to April, a year after birth, but two did not show first oestrous until August. All cows, except those few pregnant ones, went through an anestrous period from April until August at which time all began to show regular oestrous cycles again. An average of 1.65 silent heat periods was observed, and an average of 4.25 oestral cycles was observed before conception.

All females conceived, except 2 females, at an average age of 647.0 days, but the range was from 406 to 812 days. However, all of the young either aborted or died before 7 days of age, except for 2 that survived until weaning time. Seven cows did not lactate at calving and there was no development of the mammary glands. These cows that did lactate had low milk production and greatly underdeveloped udders in spite of the fact that the calves were carried a normal term of 316.4 days.

It is obvious that the breeding of water buffalo cows at the time of puberty or shortly thereafter resulted in loss of the calves and milk production of the cow. Conception is possible at this early age, but the buffalo cow is still not physiologically mature enough to normally bear offspring nor to normally lactate thereafter. The average age of these buffalo females at conception was 647 days or roughly 21.5 months. The American dairy cow is usually bred by this date and normally calves and normally lactates thereafter. It would seem that the water buffalo female is at least 6 months later maturing than the domestic cow.

The usual practice by the Egyptian farmer is to breed heifers at 2 to 2½ years of age. This practice seems sound in view of the high calf loss when heifers are bred at less than 2 years of age.

The data show a wide individual variation between animals in age at puberty but little is known of the effect of heredity and there appears to have been little effort to select for this characteristic.

2. Age at First Calving:

Age at first calving has an important bearing on early economic return on investment and on total lifelong production. In dairy cattle in the United States, heifers are usually bred to calve at 27 to 30 months of age and the average age at first calving is approximately 30 months. It has been shown in this report, that the water buffalo cow reaches sexual maturity six months later than the cow, that silent heat periods are frequent, and that the gestation period is roughly 35 days longer than the cow. Therefore, it should be expected that the minimum average age at first calving for water buffaloes would be 35 to 36 months.

Sidky (77) in a study of 713 water buffalo heifers found the average age at first calving to be 38.68 months with a range of 22 months to 60 months. The

frequency table shows 38.5 percent of the females calved 36 months of age or younger, another 40.5 percent between 38 and 42 months of age, and 21.2 percent were 44 months of age or over. Thus 1 out of 5 animals show late maturity to the extent that they should be culled before breeding, but approximately 2 out of 5 cows show definite early maturity and should be given preference in selection.

Sidky (77) found no difference in sire groups in age at first calving. Daughters of one sire tended to be like those of another in this respect. However, there was a significant dam influence and an e stimated 12 percent of the variance was due to dam effect. Data are limited and more data should be accumulated before definite conclusions can be drawn on any genetic effect.

Sidky (77) observed, however, that season of birth had a mterial effect on age at first calving. Females born in the Fall months have a greater chance of calving earlier than those born during any other season of the year. It should be understood, however, that Egyptian data tend to be biased because of the desire to have calves come in the Fall so that full advantage may be taken of the "berseem" season. In a survey of the country covering 56,798 calvings, 90 percent occurred during the Fall and Winter and 10 percent during the remainder of the year.

Similar studies by Khishin (50) and Asker and Ragab (5) substantiate the findings of Sidky. Khishin (50) reports an average of 38 months with a range of 22 to 56 months. Asker and Ragab (5) report an average of 37.44 months. Asker, Ragab and Hilmy (11) report 3.2 years or approximately 38.4 months. Asker et al. (9) estimate the heritability as 13 percent using intro-sire regression of daughters on dams.

Ashfaq and Mason (4) in Pakistan practiced a different system of management. Heifers were run with a bull as soon as they reached 800 pounds weight or 2½ years of age, whichever came first. Under this system the average age at first calving was 47 months and the range was from 32 months to 72 months. This method of management certainly resulted in delaying the calving in this herd much longer than observed in Egypt.

There is little doubt but what the present average age at first calving is around 38 months under conditions of management in Egypt. The feeding and management methods may be in part responsible for this late date since an effort is made to have the cows calve only in the Fall and Winter months. Such methods may also unconsciously select for late maturity. However, it is evident that selection for earlier maturity might tend to reduce this age provided heredity plays a part in determining sexual maturity. Heredity has been shown to have an influence on age of sexual maturity in the domestic cow and the indications are that heredity is involved in determining age of sexual maturity in water buffaloes.

Age at puberty and age at first calving varies a great deal from country to country. This is probably due to feed conditions but there are some differences due to type or breed. Ocampo (58) reports the average age at first calving for the Philippine carabao cow as 3 years, 7 months, 19 days and for crossbred carabao X Indian buffalo as 3 years, 21 days. Villegas (81) reports average age at first fertile mating for carabao as 2 years, 5 months; for Indian buffalo, 2 years, 2 months; and for crossbred carabao X Indian, 2 years, 3 months. These figures are reasonably close to the data from Egypt which shows 38 months as average age at first calving.

3. Calving Interval:

Calving interval like age at first calving has an important bearing on lifetime production. Most dairies and beef cattle producers as well expect a cow to calve every 12 to 15 months. Failure to do so usually results in sale of the cow as a "shy" breeder. Selection for regular breeding cows has done much to increase the level of production of American cattle. The water buffalo in Egypt is notoriously a shy breeder.

Ragab, Asker and Ghany (68) report an average calving interval of 541.7 ± 137.5 days with a mode of the distribution curve at 505 days. The range was from 340 days to 750 days. The first calving interval (between first and second calves) was 66 days longer than the second calving interval and 120 days longer than the 3rd to 6th calving interval.

Sidky (77) reports an average interval of 79 weeks (553 days) between first and second calves. Khiskin (50) reports an average of 585 days divided as 362 days of lactation and 231 days dry period. He reports the dry period may exceed 800 days with a calving interval of over 1150 days or in excess of 3 years. Asker, Ragab, and Hilmy (11) report an average calving interval of 1.34 years (488 days). This is the shortest calving interval reported by the several investigators. Asker, Ragab, and Ghany (9) report that the repeatability of calving interval 0.054 which indicates that length of calving interval is primarily determined by environment and management of the herd and is not a permanent characteristic of the cow.

Ocampo (58) reports calving interval of the carabao as 415.4 days, the Indian buffalo as 520.6 days, and the crossbred carabao X Indian buffalo as 501.8 days. Villegas (81) reports that the carabao had 533.6 day calving interval, the Indian 625.5 days and the crossbred carabao X Indian buffalo 456.1 days. It would appear from the two reports published 9 years apart that there was considerable improvement between the 1930 Villegas report and the 1939 Ocampo report in the management of the water buffalo in the Philippines. However, in both reports, the carabao had a much better breeding record than the Indian buffalo. The figures given by Villegas are close to those reported for Egyptian water buffalo.

Villegas (81) reports that in the Philippine carabao the preponderance of sexual activity came during August to January which is the cooler, rainy months.

The records show that 69.5 percent of the births occur from June through November. Villegas infers that the carabao has a seasonal breeding period.

A review of these reports indicates that the expected calving interval of the water buffalo is at least 500 days and may be expected to be approximately 18 months. This is far too long for economical production. However, much of this is due to management practices where the farmer does not breed as soon as possible so that the calves will come during the "right" season. Undoubtedly, silent heat also plays a large part in the delay of calving. Khishin (50) reported a correlation of 0.28 (repeatability) between calving intervals of the same cow.

Ashfaq and Mason (4) report a repeatability of 0.09 for calving interval. This is reasonably close to that observed by Asker et al (9). Khishuis estimate seems high in view of the other two reports. However, Ashfaq and Mason improved their herd management over a period of five years. They were able to materially reduce the calving interval as shown by the following table:

Calving Interval by Years (Ashfaq and Mason (4))

Year of Calving	Number of Animals		Average Calving Interval (days)
1947	19		614
1948	123		528
1949	148		484
1950	146		436
1951	114		385
Total	550	Mean:	467

These results are fairly conclusive. Herd management is largely responsible for a long calving interval and the hereditary component is almost negligible. Selection for shorter calving interval is not likely to be successful.

4. Sex Ratio of Water Buffalo Calves:

Asker and El Itriby (14) have the only report on the sex ratio of calves born in a wate buffalo herd. From a total of 4592 calves born alive in the hered, 2 389 were male calves and 2203 were female calves. This is a sex ratio of 109 males to 100 females. Chi square test shows that this is significantly different from the expected ratio of 100 to 100. (P is less than .01). This sex ratio at birth observed in the water buffalo may be due to high foetal mortality of the females resulting in the disturbed sex ratio. This explanation seems sound in spite of the fact that in most animals, male calves usually have a higher mortality than females.

5. Twinning Rate in Buffaloes:

Twins in domestic cattle vary according to breed and in some breeds may occur as much as 6 percent of the total parturitions. Asker and El Itriby (14) report that in 4579 calvings there were 13 sets of twins. This is 0.28 percent. It was

suggested that the low fertility rate may be responsible for the very low twinning rate in water buffaloes.

Chapter IV Anatomy, Blood Analyses and Body Measurements

1. The Skeleton:

The chief difference in the skeletal structure of the water buffalo and the domestic cow lies in the longer thoracic spinus processes of the water buffalo. The 4th and 5th are usually the longest and the processes gradually become shorter unter the 14 or 15 spinus process. These longer processes result in a fin-like appearance over the shoulders. MacGregor (53) also states that the scapula of the water buffalo has a convex anterior and concave posterior border, more similar to the horse than to domestic cattle.

The hoof of the water buffalo is much larger than that of the domestic cow and is more rounded. The hoof is usually black and fairly hard. White hooves are considered to be softer and poorer quality. The horns are somewhat triangular in sections caused by a ridge-like protruderance the full length of the horn. The horns are sometimes completely ringed the full length whereas the horns of the domestic cow are ringed only at the base.

2. Measurements of Live Animals:

Sidky (76) reports on the average body measurements of Egyptian water buffalo cows. The result are as follows:

Height behind the hump	141.9 cm.
Height at hook bone	139.2 "
Height at pin bone	129.5 "
Height at elbow	78.6 "
Length of body	158.6 "
Length from hook to pin bone	50.6 "
Length of neck	50.2 "
Length of ear	21.3 "
Length of face	45.2 "
Width of forehead	20.6 "
Width at pin bones	20.4 "
Width at hook bones	45.2 "
Heart girth	178.7 "
Girth of abdomen	184.1 "
Circumference of fore shank	18.8 "

3. Alimentary Tract:

Ricerra (73) studied the measurements and capacities of the alimentary tract of 10 carabao males and 10 carabao females. The males averaged 12.3 years of age and the females 14.6 years. Average live weight was 524.1 kgm for the males and 508.4 kgm for the females.

Average length of the various sections of the tract were:

	Male Average	Female Average	Average of Both Sexes
Oesophagus cm	100.70	99.65	100.18
Small Intestine m	25.68	23.25	24.47
Large Intestine m	9.49	9.04	9.27
Caecum cm	35.50	35.65	35.58
Rectum cm	42.20	41.40	41.80

Capacities of the several sections of the tract were obtained by thorough cleaning and filling with water. The total volume was obtained by measuring the water required to fill each section. The following capacities were obtained:

		Male Average	Female Average	Average of Both Sexes
Rumen	liters	71.16	70.13	70.65
Reticulem	"	3.20	2.97	3.09
Omasum	"	5.33	5.31	5.32
Abomasum	"	9.09	8.85	8.97
Small intestine	liters	23.05	21.09	22.07
Large intestine	"	15.96	16.26	16.11
Caecum	"	3.57	3.63	3.60
Rectum	"	3.95	3.98	3.96
	Total capacity	135.97	131.21	133.59

4. Composition of Blood in Water Buffalo:

The composition of blood of the water buffalo has been reported by three research papers, Hafez and Anwar (39), Kehar and Murty (48), and Balcita el al (19). In general, the three papers report on different components of the blood.

Hafez and Anwar (39) report the only complete red and white cell count of the three papers. The red cell count (ERYTHROCYTE) count was found to be 6.8 million per cubic millimeter of blood. This is nearly the same as that reported by Kehar and Murty (48) who report 6.1 million per cubic millimeter of blood. Hafez and

Anwar (39) report a total white cell (leucocyte) count of 6,700 per cubic millemeter. In differential count they found the following:

Lymphocytes	51 percent
Neutrophils	36 "
Monocytes	8 "
Eosinophils	5 "
Basophils	1- "

The specific gravity of the blood averaged 1.058 and the Ph was 7.45. The hemoglobin content was 12.98 which is higher than that of domestic cattle. Other blood constituents and their average values were as follows: Blood sugar 81.4 mg per 100 ml, plasma proteins 7.43, Plasma sodium 415, plasma calcium 10.0, and plasma phosphorus 28.

Kehar and Murty (48) report the cell volume of the blood as 35.5 percent and the hemoglobin as 12.7 or about the same as reported above. They report blood sugar as 79.4 or approximately the same as that reported above. Serum protein was 7.46, blood calcium 10.0, phosphorus 6.95 and magnesium 2.76 mg per 100 ml of serum. These are all approximately the same as that reported by Hafez and Anwar (39).

Balcita et al (19) report that the water buffalo blood had no measurable carotene in their blood plasma whereas cattle had 126 ug per 100 ml of plasma. However, in Vitamin A content buffaloes had 176 ug and cattle only 127 ug per 100 ml of plasma. Cattle had significantly more calcium in their blood than did the water buffalo, 10.8 versus 7.7 mg per 100 ml of plasma. The lack of carotene in the blood ties in with the lack of carotene in the milk of the buffalo.

Chapter V Milk and Butter Fat Production in the Water Buffalo - The water buffalo is essentially a three purpose animal, since it is used for milk, meat, and work. Under usual small farm conditions in the Oriental world, the water buffalo cow is considered first an excellent work animal, and milk production is only secondary. On larger farms, 50 acres or more, milk production is of primary importance and the buffalo cows are usually not worked. For this reason, a real effort has not been made to select animals for high milk production. In Egypt, research work in improvement is of great interest to the animal husbandman in recent years. India also reports research in selection for milk production.

1. Milk Production of the Water Buffalo Cow:

Milk production in the water buffalo is notoriously poor, yet variable enough to indicate the possibility of genetic improvement in this characteristic. Sidky (76) reports averages of 3408 to 3975 pounds of milk produced per lactation period. Variations of 500 to 8500 pounds were observed. Figure 1 shows the frequency distribution in 500 pounds units. The mode occurs at 4000 pounds per lactation. Sidky (76) reports the average production of heifers at 3000 pounds, but of 300 heifers recorded 90 milked less than 200 days and their data were excluded from the averages as being abnormal. A total of 110 heifers milked more than 305 days, however, and their yield was taken only for the 305 day period. Thus, 100 heifers

produced milk for a period of 200 to 305 days. This would be considered a very short lactation period in the average dairy cow. Sidky (76) also reports selected sires whose daughters average as high as 4350 pounds of milk. Phillips reports Indian water buffalo cows with 3000 to 5000 pounds of milk with occasional animals producing as high as 10,000 pounds of milk. Olver (60) reports individual records of best producers in India ranging from 6600 to 9900 pounds of milk per lactation period.

In general, it can be concluded that the average production of milk by the water buffalo cow at the Experiment Stations in Egypt is 3000 to 4000 pounds of milk with variations of from 500 to 10,000 pounds. There are no records of milk production under farm conditions. Individual breeds vary also and some breeds, such as the Murrah breed of India, may range from 3000 to 5000 pounds with individual cows running as high as 10,000 pounds. It is certain that there is ample genetic variation at present to assure success in breeding for higher production. There are no local, national, or international milk recording societies or organizations for water buffaloes today in the world and thus the genetically superior animals may be overlooked.

The effect of age on total milk yield and length of lactation period has been studied in one herd of water buffaloes by Ragab, Asker, and Ghazy (67). It was found that age at first calving had a significant effect on the total milk yield not only in the first lactation, but in the yields of subsequent lactation periods up to the fourth. In other words, the milk yield of buffaloes increased with the increase of age at first calving up to the fourth lactation period. The regression coefficients indicated an increase of approximately .4 pounds of milk for each day increase in age at first calving. This finding, if it holds true for other breeds and herds of buffalo, is of major importance in developing a selection and breeding program since selection for earlier maturity might result in selection for lower milk yield.

The results also show that total milk yield increased with advance of age until maximum production was obtained at the third lactation period of approximately 6.5 years of age, after which it declined rather rapidly. The data are limited but Figure 2 shows the average production for the first 5 lactations compared with the smoothed curve of the diary cows in the United States. Quite obviously, if these data are representative of the species as a whole, the buffalo cow increases its yield much more rapidly as it matures and after maturity, the loss in milk yield being much greater with advancing age than in domestic cattle. More data are needed to confirm this point, and to establish age correction factors for the buffalo.

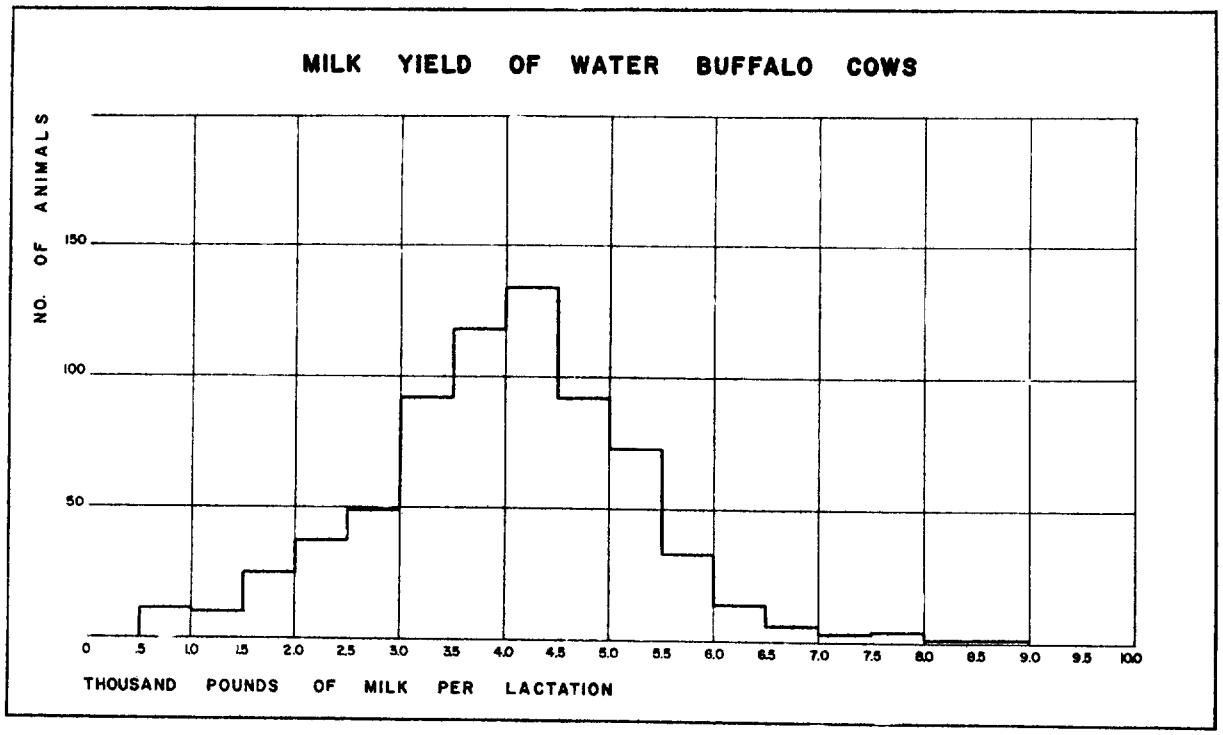


Figure 1. Distribution of Total Milk Production of Water Buffalo cows. Data from Sidky (53)

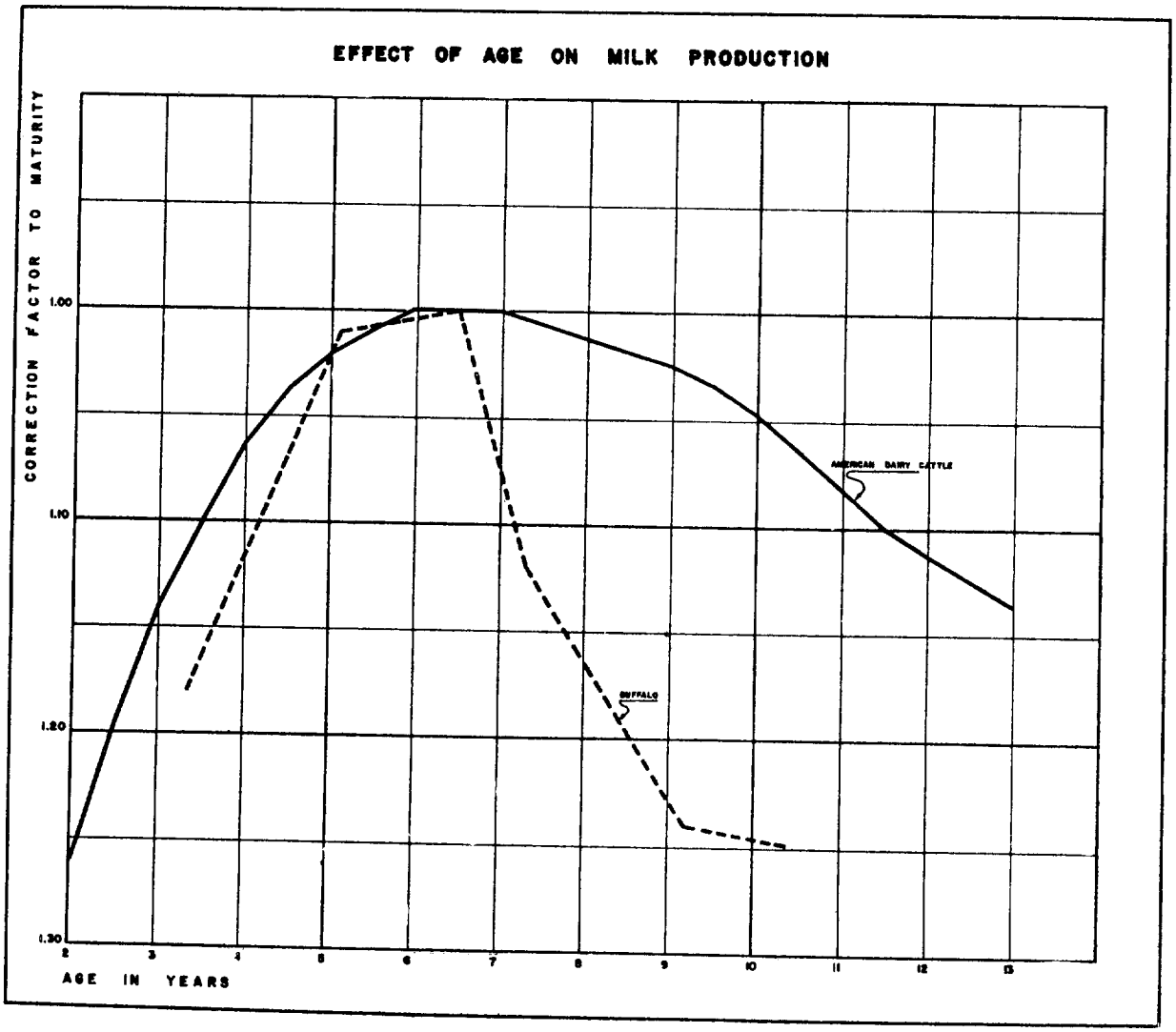


Figure 2. Effect of age on milk production of water buffalo compared with dairy cattle in the United States.

Similar to that found in dairy cattle, young buffalo cows have a tendency toward long lactation periods than older cows. The correlation between age and length of lactation was - 0.322 and the regression coefficient was - 0.097.

The same investigators also studied the effect of season of calving, dry period, and calving interval on milk yield, and length of lactation period in buffaloes. Although it was observed that buffaloes calving in February and March were the best yielders, statistical analysis indicated no significant effect of month of calving on yield of buffalo cows. The length of the preceding dry period did have a significant effect on total milk yield and accounted for 6.4 percent of the variation in milk. A correlation of 0.384 was observed between calving interval and total milk production. However, the optimum dry period was 60 to 90 days as observed in cattle since this group had the highest yield in all lactations. The current dry period, that is the dry period at the end of the current lactation period did not significantly affect the total milk yield. This would indicate that degree of pregnancy at the end of the lactation period had little effect on the total milk yield. It would seem then that selections for buffalo cows with shorter dry periods and management changes to reduce the length of dry period at least to 90 days would not adversely affect the milk production of the cow.

Asker, Ragab, and Hilmy (13) made a study of one here of water buffalo where selections for milk production has been made for a period of 20 years. The culling differential was low, 147 to 271 pounds of milk per lactation. Heritability of milk production was estimated to be 0.27. Based on this estimate and the number of years per generation, the annual genetic gain in milk yield was 18 pounds. Much more rigorous selection plus use of younger animals for breeding can raise the annual genetic gain.

Asker, Ragab, and Ghany (9) report heritability estimates of milk production in the water buffalo. Heritability estimates based on intro-sire regression of daughters on dams for milk production was 24 and for length of lactation was 11. By paternal half-sister correlation, the estimate was 25. The repeatability of milk yield was 0.376 and for length of lactation period repeatability was 0.263 and heritability was 11. Table 2 shows all the estimates of repeatability and heritability of milk production. Three of the five repeatability estimates are close to .36 but the other two are much higher. The heritability estimates are approximately equal and are very close to those observed in dairy cattle in the United States. Therefore, methods of selection and improvement already proven with dairy cattle in the United States would be equally applicable to herd improvement work with the water buffalo.

Table 2: Summary of estimates of Repeatability and Heritability of Milk Production of the Water Buffalo

Source (Author)	Repeatability		Heritability	
	No. Animals	R.	No. Animals	H.
Asker, Ragab, Ghany (9)	796	0.376	64	24
Miss Hilmy	192	0.665	-	-
Alim & Ahmed (2)	517	0.550	-	-
Ashfaq & Mason (4)	376	0.368	277	18
El Itriby & Asker (24)	1270	0.362	102	20

The average milk and butter-fat yield per day during lactation is shown in Figure 3. Ragab (64) shows that the rate of decline of milk production as the lactation period progressed was always at a slower rate than that for Egyptian cows.

2. Composition of Buffalo Milk:

The composition of the water buffalo milk is materially different than that of the domestic cow. Hassan (45) analyzed samples of both cows' milk and water buffalo milk. Large enough samples were used to make their results conclusive. Individual samples from 100 cows and 100 buffaloes were taken at regular intervals throughout the year. Table 3 shows their results. He also analyzed bulk samples from herds and found essentially the same results except there was no significant difference in specific gravity. Seasonal variations showed the buffalo more variable from season to season in all milk constituents than the cow. This was especially true of total nitrogen and casein nitrogen. These both are lower in summer months than in the winter months. The indications are that the buffalo is more affected by the hot season than are the cattle.

Table 3: Comparison of Composition of Cow and Buffalo Milk

	Ave. of 100 samples of cows' milk	Ave. of 100 samples of buffalo milk	Difference between the two milks	Statistical Signif.
Specific gravity at 60°F	1.0331	1.0325	.0006	.05
Percent of fat	4.57	6.64	2.07	.01
Solids not fat-percent	9.25	9.92	0.67	.01
Total nitrogen-percent	0.557	0.616	0.059	.01
Casein nitrogen-percent	0.442	0.501	0.059	.01
Casein number	79.34	81.34	2.00	.01

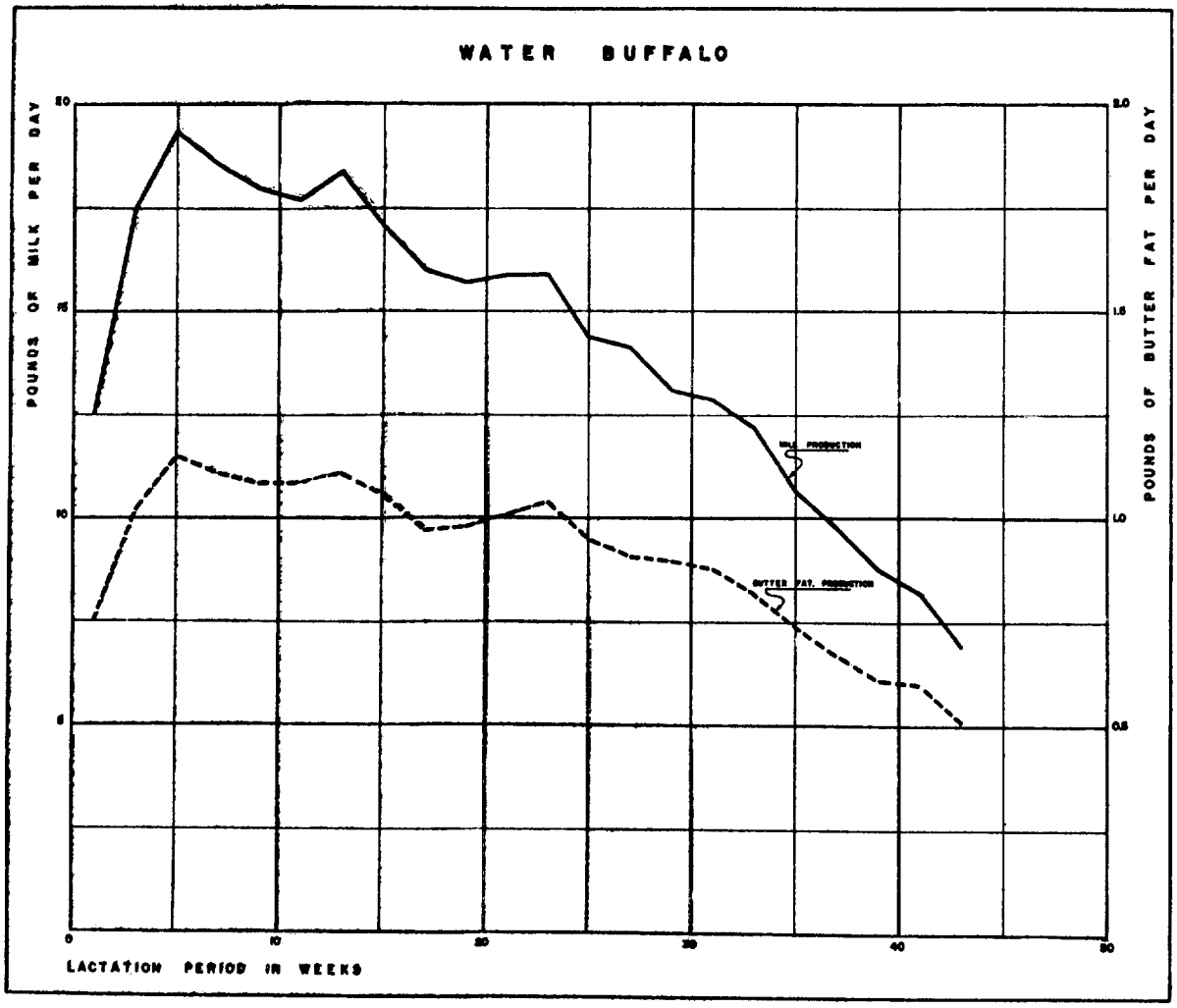


Figure 3. Lactation curves for Milk and Butter-fat production for water buffalo cows. Data from Maghrabi (35)

Ismail and Nagoumi (46) studied the major nitrogren constituents of buffalo and cows milk. In Table 4 are shown the results of their studies.

Table 4: Extremes and averages for the major nitrogen constituents of buffalo and cows milk.

SPECIES	VALUE	Total Nitrogen	Casein Nitrogen	Albumin and Globulin	Casein Number	Albumin Globulin Number
Water Buffalo	Max.	0.720	0.555	0.071	79.70	10.63
	Min.	0.613	0.466	0.049	73.46	7.29
	Average	0.668	0.517	0.059	77.40	8.83
Egyptian Cow	Max.	0.579	0.449	0.070	80.52	13.04
	Min.	0.500	0.364	0.049	72.80	9.06
	Average	0.534	0.411	0.057	76.97	10.76

Negoumi (57) found that the citric acid content of buffaloes milk was 0.224 percent compared to 0.171 percent for cows milk. Youssif (57) in an analysis of vitamin content of buffalo and cows milk obtained the following results:

	Buffalo	Cow
Whole Milk:		
Carotenoids ug/100 m/of milk	nil	22.66
Vitamin A ug/100 m/of milk	43.69	41.74
Vitamin A potency IU per m/of milk	174.8	204.8
Riboflavin mgm/1 L. milk	2.41	1.87
Butter-fat:		
Carotenoids ug/1 gr. of fat	nil	4.66
Vitamin A. ug/1 gr. of fat	6.01	8.58
Vitamin A potency IU per 1 gr. of fat	24.0	42.2

Oloufa et a. (59) studied the effects of feeding the thyroprotein to buffalo cows during one lactation period. One group of four cows were fed a basal ration plus 15 grams thyroprotein per day and the control group of four received only the basal ration. An increase of 4.18 percent in yield was observed in milk yield, though the difference was not significant. The feeding of thyroprotein did not affect the butterfat percentage. Thyroprotein also caused higher body temperature, respiration rate, pulse rate, and the animals required more services per conception than the control animals. Asker, Ragab and Kamal (11) found that feeding of thyroprotein did not affect the specific gravity or composition of buffalo milk.

Asker et al. (8) studied the relationship between milk production and certain body measurements in Egyptian water buffalo. Comparison of the buffalo data with that for Holstein cattle in the United States shows that the measurements of mature buffalo cows have approximately the same coefficient of variability as the Holstein. The highest correlation with milk yield, 0.24, was observed with height of hips. The correlation with width of thurl and width of hips with milk yield was also statistically significant. However, all correlations between milk yield and body measurements are too small to indicate much relationship between conformation and milk yield in water buffaloes. These authors justly conclude that since these correlations are low that milk recording should come first in any improvement program.

2. Butter-fat Production in the Water Buffalo:

The water buffalo is noted for the high percentage of butter-fat in its milk. This is one of its outstanding traits when consideration is given to the conditions and use of buffalo milk in the Near and Far East.

This region consists of a hot humid climate, where farms are small and local refrigeration is non-existent. Fresh milk cannot be kept longer than a few hours without souring. It is common practice, therefore, to make clarified cooking oil from the butter-fat and cheese from the skimmed milk. In the form of cooking oil ("ghee" or "semna") and cheese, the milk may be stored for long periods of time and thus forms a most important part of the diet of the small farmer. No dairy cow can fulfill the actual needs of the small farmer as well as the water buffalo because he gets more butter fat and more cheese per 100 pounds of milk from the buffalo cow. This fact will continue to be true until refrigeration is universal throughout this region. This is not likely in the foreseeable future.

a. Distribution and variations in butter-fat test.

Sidky (76) reports the average butter-fat test as 7 percent. Aloufa et al. (59) report 6 to 6½ percent. Phillips (62) reports 7 to 12 percent in various countries and under widely varying conditions. Olver (60) shows tests from 6.3 to 8.7 percent and total butter-fat yields of 409 to 640 pounds of butter-fat per lactation. Maghrabi (54) reports an average for Egyptian buffalo of 7.11 percent and a range from 4.10 to 12.00 percent.

Two conclusions can be drawn from the several reports, namely: (1) the butter-fat test in water buffalo milk is much higher than that of domestic cattle and averages more than 7 percent; and (2) the butter-fat test is much more variable than that of domestic cattle especially that observed within breeds.

b. Butter-fat production per lactation

The total butter-fat production per lactation in water buffalo is comparable

with that of the European breeds in spite of the low milk production shown above. For example, 4000 pounds of 7 percent milk will produce 280 pounds of butter-fat with the water buffalo whereas it would take 7000 pounds of 4 percent milk to produce 280 pounds of butter-fat for the European breeds. In Figure 4 is shown the production of water buffalo cows compared with Brown Swiss cattle in the United States under DHIA testing. It can be seen from the chart that although the Brown Swiss has a slightly higher average than the water buffalo, the mode of the distribution diagrams is the same for both species, that is 300-349 pounds of butter-fat per lactation. The distribution of the Brown Swiss is biased since poor producers do not get into the DHIA records published by the breed associations whereas the records shown for the water buffalo do not contain this bias. Repeatability of total butter-fat yield per lactation was found to be .43 on 136 lactations from 40 buffalo cows. This is approximately the same as repeatability of milk yield and indicates that butter-fat production is a permanent characteristic of the individual cow.

These data indicate that on the basis of butter-fat alone, the water buffalo competes favorably with the domestic cattle. Since in the tropics with no refrigeration, butter-fat is a valuable produce and fluid milk is likely to spoil in a few hours, it is understandable that the water buffalo is popular with the small farmer.

Chapter VI. Longevity and Mortality Rate

1. Longevity and Mortality of Water Buffalo

A study by Asker and Itriby (14) reported on the mortality rate of water buffalo calves from birth to 3 years of age. The data were obtained from two experiment stations belonging to the Ministry of Agriculture at Sakha in the northern delta and Sids in the valley 100 kilometers South of Cairo. A total of 4598 calves were included in the study of which 1517 calves died before reaching three years of age. This is 33.0 percent of the calves. Most of the deaths occurred between birth and six months of age, 81.8 percent. Death rate was also higher in males then in females, 17.4 percent and 15.6 percent respectively. Death rate by ages were as follows:

Birth to 6 months	81.8 %
6 months to 12 months	10.9 %
12 " to 18 "	2.4 %
18 " to 24 "	1.3 %
24 " to 36 "	3.6 %

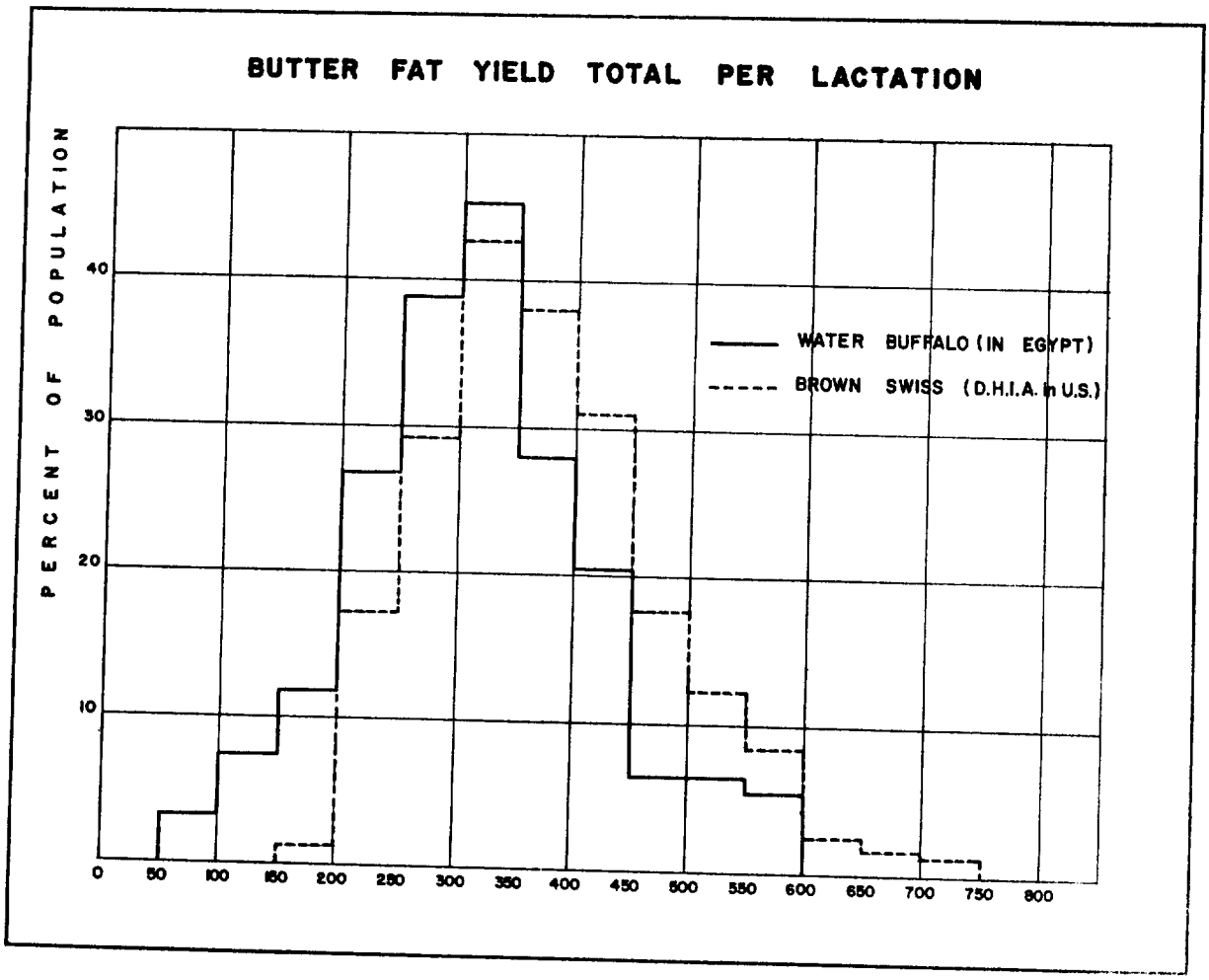


Figure 4. Total Butter fat yield per lactation of water Buffalo cows compared with Brown Swiss (DHIA) records in the United States.

These death rates are much higher than those in dairy cattle in the States and probably higher than that experienced by the farmers of Egypt. Causes of death were listed as enteritis, pneumonia, navel infections. The writers believe that the death losses can be materially reduced by improving the sanitary conditions. In three years of the 15 years covered, outbreaks of haemorrhagic scepticemia caused the death rate to rise to as high as 50 percent.

Death losses during the winter months accounted for one-half to two-thirds of the deaths and deaths were lowest during the summer months. Abortion caused only 1.1 percent of the losses.

Asker, Ragab and Hilmy (11) made a study of longevity in the water buffalo cows. The data cover 484 lactations of 175 buffalo cows. The average productive life of the animal was determined by the average number of lactations which the animals remained in the herd. The average number of lactations that the buffalo cow remained in the herd was only 2.45. This is low in comparison to dairy cattle although in age the buffalo cow approaches the average age of dairy cattle because of the late date of first calving and the long calving interval. Calculated on the basis of years of age, the buffalo cow remains in the here until 6.48 years of age. The average age at calving time was 5.14 years which is about 6 months younger than the average of dairy cattle in the United States. The writers believe, however, that the averages shown in this herd that they studied are less than in most commercial farms because of the culling used in this herd to raise the production level of milk. Alim (2) in another study on a commercial herd found that the average productive life of the water buffalo cows was 5 lactations. This would mean the average age was approximately 10 years of age for the buffalo cows. This is much older than dairy cows are kept in most diary herds in the United States. Just what is the true figure for buffalo cows on farms in Egypt is not known, but it probably approaches the figure given by Alim.

El Itriby and Asker (23) studied the longevity and period of use on buffalo bulls on Ministry of Agriculture farms and Agricultural Extension centers in Egypt. The average age when first used for service was 3.7 years, based on life histories of 551 buffalo bulls. The range was from 9 months to 5.5 years of age. The average age at disposal of the bull was 7.7 years. However, the average age of 389 bulls still in service at the differenct agricultural centers was 8.7 years. Causes of disposal were: disposition (bulls became unmanageable) 8.6 percent, sterility 21.0 percent, senility 32.1 percent, and low milk production of dam 38.3 percent. The annual replacement rate was only 5 percent.

2. Generation Interval

Generation interval is an important consideration in the improvement of any class of livestock. The more rapid the rate of generation turnover the more rapid improvement may be possible in the species. In domestic cattle in the United States, the usual generation interval is 5 to 6 years. The writer (51) found in beef cattle an average of 5.5 years between generations.

In the water buffalo, it should be expected that the generation interval is longer than in the cow because of the late age at first calving, the long interval between calves, and the usual practice of using bulls for long periods of time. Asker and Ragab report an average of 6.05 years but Khiskin (50) reports an average of 7.68 years from a different population. In the first report, selection pressure accounts for the low figure. It was found that only 25 percent of the buffalo cows were kept for a second lactation. The average age of sires in the water buffalo was 6.78 years and that of the cows only 5.09 years. The figure given by Khishin (50) is more truly representative of the average conditions in Egypt.

It would appear that with high selection pressure, it is not possible to reduce the generation interval much below the average for cows in the United States. Selection for earlier sexual maturity and higher fertility would do much to reduce the present figure.

Chapter VII. Growth of Water Buffaloes

Data on growth of the water buffalo is quite limited because of the lack of livestock scales at the many experiment stations, or because management practices do not make scales readily available.

1. Birth weight

Tantaowi and Ahmed (79) studied some of the factors influencing birth weight in buffaloes. The average birth weight of all calves was 39.80 kgs. (87.6 lbs), male calves averaged 41.23 kgs. (90.7 lbs), and female calves 38.15 kgs. (83.9 lbs). Differences between sexes was statistically significant. Calving sequence (i.e. whether first, second, third, etc. calf from each cow) has a significant effect on birth weight. Birth weight was increasingly heavier from the first to the fourth calf, after which there was no change in birth weight of calf. The average of cow at the time of the fourth calf was 7.40 years. At this same time, the buffalo cow reached her maximum weight. This is much later than that observed in cattle by many investigators. In cattle, also, the writer found that there was little change in birth weight of cattle after the second calf, when 3 years old. This would seem to indicate that the buffalo cow matured at a much later age than the domestic cow.

A correlation of 0.289 was observed between birth weight of calf and weight of cow at calving time. The writer (51, 52) observed a correlation of 0.26 in range catlte and 0.22 in a purebred Shorthorn herd under farm conditions; and Tantaowy and Ahmed (79) report a correlation of 0.230 in Egyptian cattle. These correlations are all of the same relative value and indicate that size of the cow has an influence on the birth weight of the calf. Since in all of these studies the cows were carried under good environmental conditions, weight of cow is an index of her capacity of body but fluctuations in degree of fleshing are of little importance.

Tantaowy and Ahmed (79) and Asker and Ragab (7) observed no significant effect in water buffalo due to month of calving. Asker and Ragab (7) observed significant differences between sire group and a heritability estimate of .561. Significant sire effect on birth weight has been proven many times in cattle.

It would seem that the same general factors influence birth weight in water buffaloes as effect birth weight in cattle. If this is true and every evidence points toward it being true, then selection methods developed in the United States with cattle would be applicable to water buffalo.

2. Birth to two years of age

Ahmed and Tantaowy (1) made an analysis of growth of Egyptian cattle and buffaloes up to 2 years of age. Figure 5 shows the average weight of Egyptian buffalo compared to the average weights of Italian buffalo reported by Maymone (55) and weights of Holstein and Jersey females in the United States (Perry) (61). The Egyptian and Italian buffalo calves are about the same for the first 6 months and both are slightly heavier than the Holstein. At six months of age there is a break in the curve and at one year of age the Egyptian buffalo females are more nearly like the Jersey females in the States. The Egyptian buffalo continues on at about the same rate as the Jersey until 2 years of age. The Italian buffalo reported by Maymone, however, continue to grow at about the same rate of the Holstein. A study of gains of Egyptian buffalo during each month shows that there were two periods of rapid growth and two periods of relatively poor growth. Gains per month were good from birth to 3 months of age and again from 16 to 22 months. During the usual seasons of calving, these would correspond to the "berseem" season, when green clover is available usually November to May. The indications are that the difference in growth between the Egyptian and Italian buffaloes is due to nutritional deficiencies in the feeding of buffalo calves of Egypt during the summer season.

Chapter VIII. Meat Production of the Water Buffalo

1. Veal Production

Badreldin (18) weighed a group of 25 male buffalo calves before slaughter at 30 to 40 days of age and then followed the calves through the slaughter plant. The average live weight was 135 pounds. The average carcass weight (including liver, kidney, heart, mesenteric fat, and tail) was 88.9 pounds. The average dressing percent was 65.75 percent. This is much higher than would be calculated for dressing percent in the United States because of the inclusion of edible offal noted above. Badreldin (18) states that the meat of the buffalo veal is very tender and liked by the consumers while the meat from older animals is tough, coarse and less palatable.

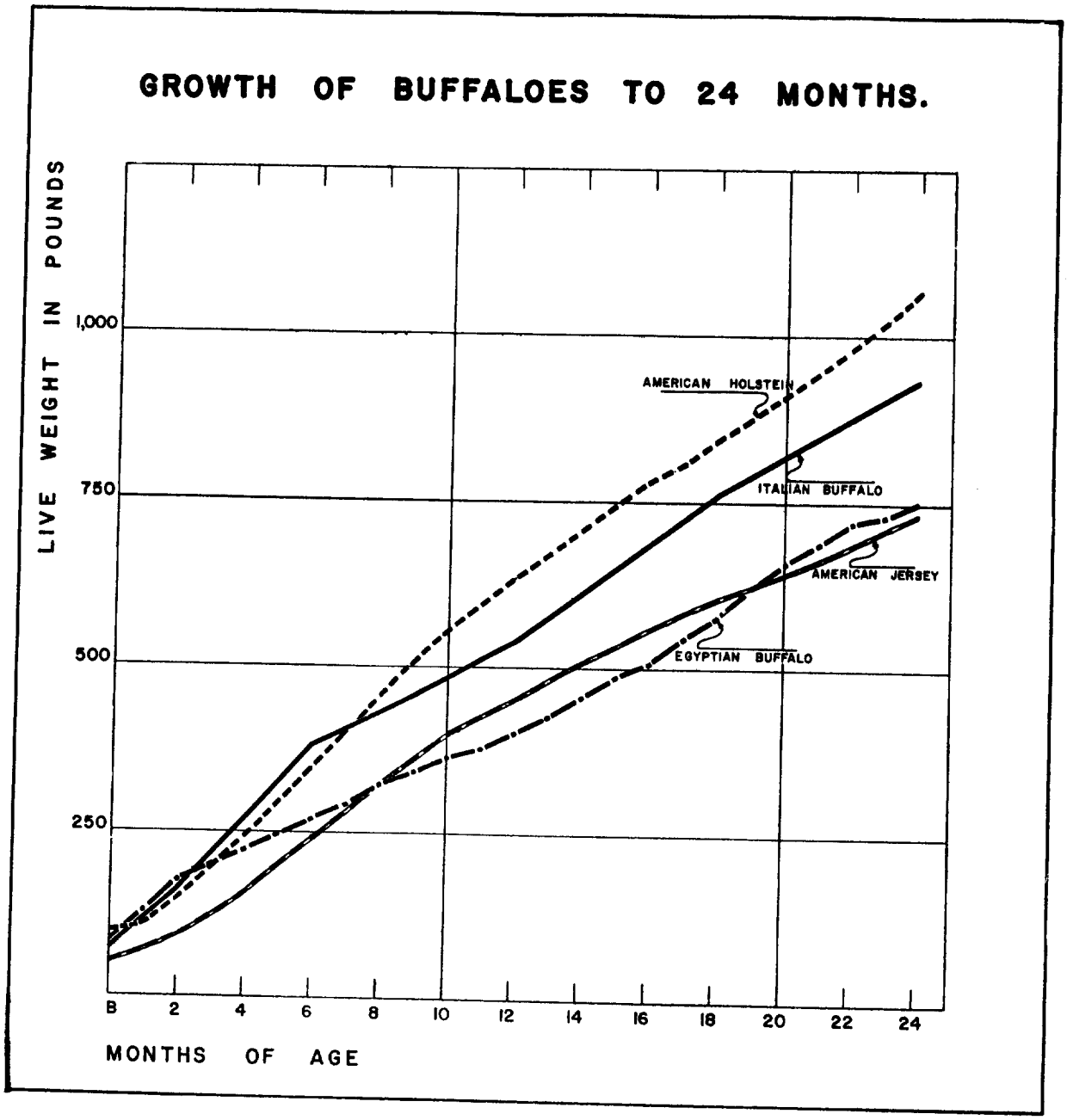


Figure 5. Growth of Egyptian and Italian buffalo compared with standard weights of Holstein and Jersey cattle in the United States.

2. Beef Production

Maymone (55) studied the slaughter records on both male and female buffaloes, adult and 1½ years of age, when the animals had been carried on "half-free" (translated literally) pastures. The average dressing percent of the several groups were as follows: adult females 47.72 percent, 1½ year old females 49.00 percent, and 1½ year old males 49.26 percent. Cut-out yields were as shown in Table 5. In general, the carcasses are much larger in fore quarter than beef type cattle, but the carcasses did yield a fairly large percent of edible meat in proportion to bone. Maymone also shows the fat of the buffalo carcass is lower in melting point than that of cattle fat. Melting point was 36 - 37 degrees Centigrade.

TABLE 5: Cut-out yields of fore and hind quarters and percent bone and edible meat of carcasses from Italian buffaloes*

	Percent fore quarter	Percent hind quarter	Percent lean & fat in carcass	Percent bone in carcass
Adult female buffalo	55.50	44.49	79.89	19.66
1½ year old female buffalo	50.73	49.26	79.44	19.76
1½ year old male buffalo	52.32	47.68	79.82	20.09

*Adapted from Tables 12 and 13 of Maymone report (55)

Results are meagre on meat studies, and few conclusions can be drawn. Mature or 1½ year old animals had poor dressing percentages in spite of the fact that they were apparently kept on reasonably good pasture prior to slaughter. The carcasses produce heavy fore quarters where the poorer cuts of meat are located. Obviously, there has been no selection for meat conformation since the water buffalo has been kept primarily as a dairy animal and as a beast of burden. It is doubted whether any effort should be made to improve meat quality in view of the much needed improvement in other characteristices.

Chapter IX. Disease Resistance of the Water Buffalo

The water buffalo in Egypt is said by most farmers to be resistant to most of the diseases common to cattle. There is very little evidence either to substantiate or deny this claim. Unfortunately, data are not available in Egypt but conclusive studies should be undertaken to determine this point on large enough numbers of buffaloes. The only study available is a small one by Reda and Oloufa (70).

1. Infectious Diseases:

Infectious diseases studied were: foot and mouth; Texas fever; cattle plague; stiff sickness; and tuberculosis. Cattle carried on the same farm were compared with water buffaloes. A total of 43 cattle were affected with the above diseases and only 12 buffaloes were affected out of a total of 394 cattle and 261 buffaloes. The cattle has 12 deaths as compared to 2 for the buffaloes. The buffalo cows did not have a single case of Texas fever and cattle plague. The two deaths in buffaloes were from foot and mouth and tuberculosis. Chi square test shows significant difference between cattle and buffalo in incidence of infectious diseases.

2. Non-infectious Diseases:

Non-infectious diseases studied were: Pneumonia; enterities; Tympanitis; indigestion; ascetis; metritis; mastitis; uremia; jaundice; pyemia; mange; conjunctivitis; lameness; wounds and abscesses; and fractures. In 394 cattle a total of 222 cases of the above diseases occurred whereas in 261 buffaloes a total of 125 cases were observed. Deaths were 36 for cattle and 29 for buffalo. In the digestive diseases, enteritis, tympanitis and indigestion, there were 77 cows affected and 58 buffaloes. On percentage basis, 19.5 percent of the cattle and 22.2 percent of the buffalo were affected by digestive disorders. The incidence of digestive disorders between the two species is not statistically significant.

The average mortality rate for both infectious and non-infectious diseases was about the same for both species, 12.18 percent for cattle and 11.87 for buffaloes. Thus, although a significantly fewer buffaloes were affected, of those affected, 23.3 percent died whereas only 18.1 percent of the cattle died that were affected. The major portion of the deaths in buffaloes was from enteritis.

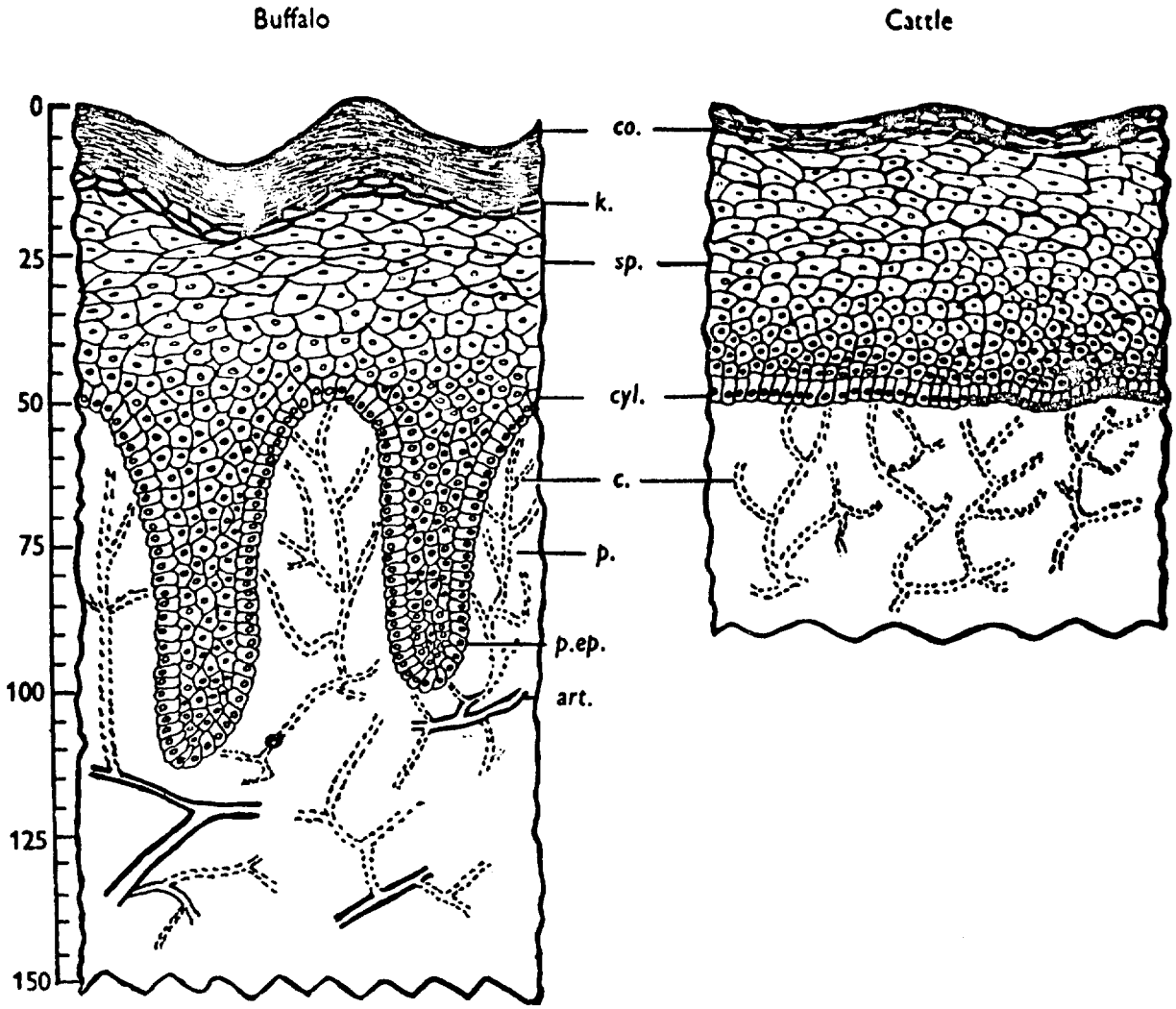
Chapter X. Skin Structure of Water Buffalo

Hafez, Badreldin, and Shafei (41, 42) made a histological study of the skin structure of the water buffalo and Egyptian cattle. The study included sections from 16 regions of the body of each animal, three male water buffalo and three cattle males. Also, skin sections were taken from two buffalo embryos (one month and five months old) and one buffalo at birth. The average skin thickness was 6.5 mm. for the mature water buffalo and 4.3 mm. for the cattle. Skin thickness varied from one body region to another but in all regions the water buffalo skin was materially thicker than that of cattle. The thickest skin in both species was over the top of the neck.

Histologic examination showed many differences between the two breeds. The outer layer of the skin (stratum cornium) was 11 u in buffaloes and only 5 u in cattle. In the buffalo, the outer layer (epidermis) was characterized by the presence of down growths (Figure 6). Pigment granules appeared in both species but were brown in the buffalo and yellow in the cattle. The degree of pigmentation was higher in the buffaloes than in the cattle.

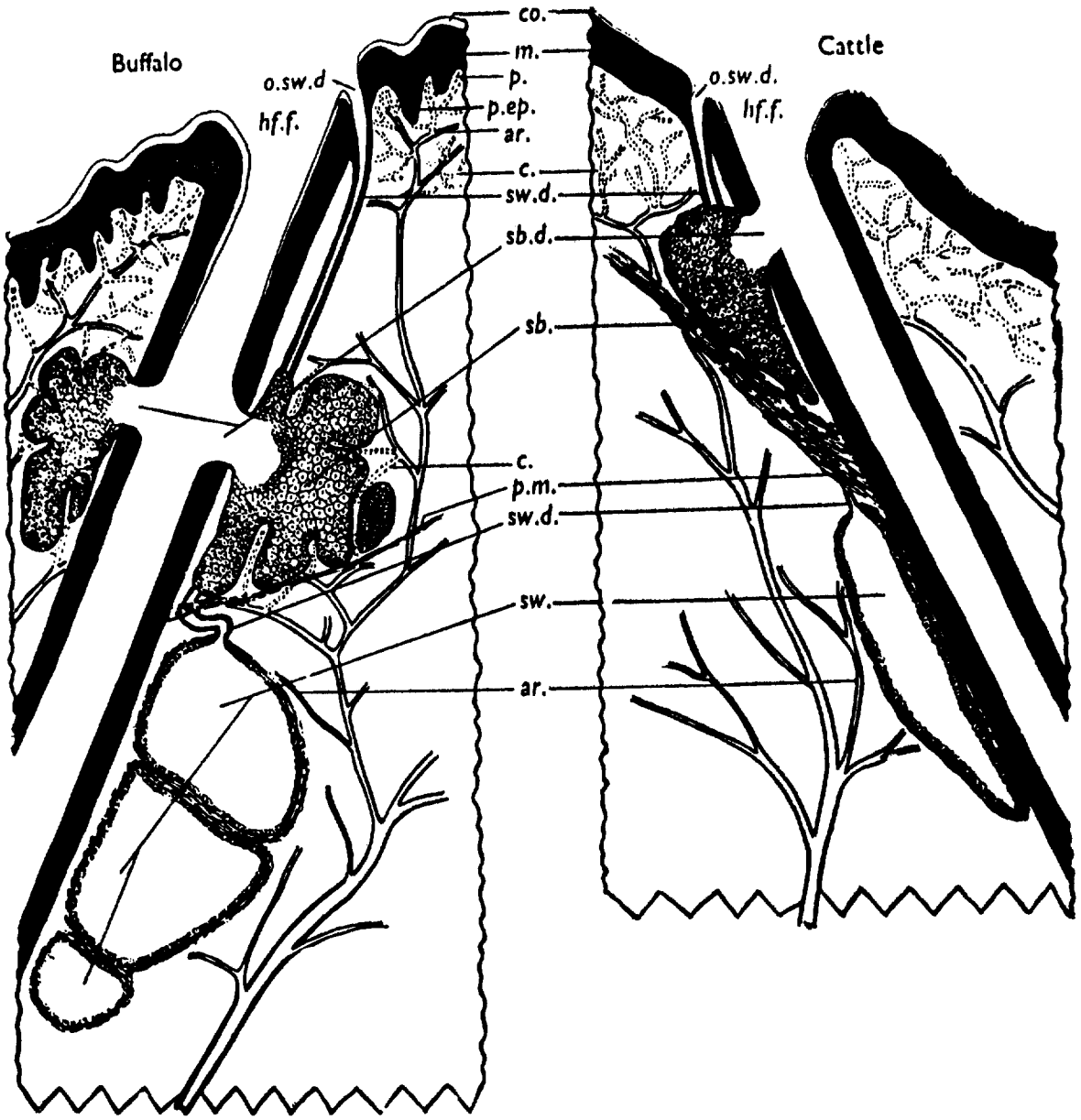
The under layer (sub-epidermal) was thicker in buffaloes than in cattle and the oil glands (sebaceous glands) are located deeper in the buffalo than in the cattle. The sebaceous and sweat glands levels of the buffalo were thick due to the large size of the glands. The number of hair follicles varied from one body region to another and was significantly different between the two species. The average number per square cm. was 2633 for cattle, whereas the buffalo had only 394 per square cm. There were marked differences in the location, shape, and number of sebaceious glands per hair follicle in the two species. (Figure 7). The sebaceous glands of the buffalo were better developed than in cattle.

Measurements of the sweat glands of the two species showed that the average glandular surface per single gland was 0.247 sq. cm. in buffaloes and 0.124 in cattle. However, since the number of sweat glands is the same in species as the number of hair follicles, the glandular surface of sweat gland per sq. cm. of skin was 1.07 sq. cm. in the buffalo and 3.08 sq. cm. in the cattle. Thus, the sweat gland surface area per unit of skin area is three times greater in cattle than in buffalo. However, age has a material effect on the number of hair follicles and sweat glands per sq. cm. of skin in the buffalo. In the one month embryo, the number of sweat glands per sq. cm. of skin was 2880. The number increased to 10,560 per sq. cm. in the five months old embryo, but at birth the number was reduced to 1248 per sq. cm. These writers estimate that the total number of hairs in the entire skin at birth for the water buffalo was 8,110,000 and 8,040,000 for the adult water buffalo. It would appear then that with advancing age, the skin merely stretches resulting in material decreases in hair density per sq. cm. of skin. Such is not true in cattle.



Epidermis and sub-epidermal level in buffaloes and cattle shown semi-diagrammatically.

Figure 6. Text figure from Journal of Agricultural Science (Hafez, Badreldin and Shafei) through courtesy of the Editor.



Histological differenees between buffalo and cattle skin shown semi-diagramatically.

Figure 7. Text figure from Journal of Agriculture Science (Hafez, Badreldin and Shafei) through courtesy of the Editor.

There were significant differences between the two species in the distribution of blood vessels in the skin. In buffaloes, the arteries branched more frequently giving rise to many arterioles and capillaries. In the subepidermal layer, the arterial branches appeared in the buffalo skin but were absent in the cattle skin. The lymphatics were also more frequent in buffalo skin than in cattle skin.

In practical application of this study, the buffalo is not able because of its skin structure, to withstand long periods of direct solar radiation but it is more adapted to shade and semi-aquatic conditions than are cattle. Under shade or in the water, the buffalo has a better cooling system than the cow. This conclusion can be drawn from the fact that the buffalo has less hair, less sweat glands but thicker skin and better circulation of blood in the skin than cattle. These characteristics, typical for the buffalo, make it unsuitable for desert areas or for long exposure to direct solar radiation. The scarcity of hairs on the body surface is typical of semi-aquatic mammals. In cattle, the relatively heavy hair coat, more numerous sweat glands, and thinner skin is a better heat regulating mechanism for direct solar radiation and thus more readily adapted to arid zones. These conclusions are borne out by heat tolerance tests in both shade and sun of the two species.

Chapter XI. Heat Tolerance Tests of Water Buffalo

The reactions of animals to various environments has been of great interest in recent years to animal husbandmen all over the world. The tolerance of various species to heat is of special importance since a large part of the world's undeveloped areas lies within the tropical and subtropical region.

Species and breed reactions to heat are the result of natural and artificial selection for this trait. The differences in reaction are physiological, anatomical, and morphological facotrs and the interaction of these factors probably with psychological adjustment. For example, it is well known that thickness of skin and number of sweat glands vary according to species, breed, sex and age of the animal, and body region of the same animal. In other words, the heat regulating mechanism is typical for each genus or species.

Rhoad (72) first demonstrated that there breed and species differences in response to direct solar radiation and high atmospheric temperatures. From his studies, he developed the Iberia Heat Tolerance Test which was based on body temperature of the test animal under direct solar radiation.

Badreldin and Ghazy (17) subjected the water buffalo, native Egyptian cattle, and Shorthorn cattle, to tests similar to the Iberia Heat Tolerance Test. In the first test, the animals were placed in the sun for 2 hours

(10 A.M. to Noon) and at noon tied in the shade for 2 more hours. In the second test, the animals were put in the sun at Noon for 2 hours and then returned to the shade for 2 more hours. In both tests, the results were essentially the same. Respiration rate, pulse rate, and body temperature all rose when the animals were placed in the sun. The water buffalo suffered from the heat the most and Egyptian cattle the least, but water buffaloes recovered faster when placed in the shade. Body temperature of the water buffalo, for example, rose from 38.3 degrees C. to 39 degrees, whereas the Egyptian cattle's rose from 38.3 to 38.4. Respiration rate in the buffalo rose from 35 per minute to 80 per minute as compared to the Egyptian cattle that changed from 38 per minute to 40 per minute. The conclusion seems sound that the water buffalo is less heat tolerant than the Egyptian cattle when exposed to direct solar radiation.

Two other reports by Asker, Ghany, and Ragab (6, 10) show that the heat tolerance test designed by Rhoad proves the buffalo has the poorest heat tolerance of any of the animals studied. Even purebred Shorthorn cattle had a better heat tolerance score than the buffalo. Asker et al. report that the increase in body temperature of the buffalo was 4 times that of Egyptian cattle. Respiration rate of the buffaloes doubled in 2 hours exposure to the sun. In general, all reports on heat tolerance tests as designed by Rhoad show the water buffalo to be very poor in its heat regulating mechanism. This is due to the fact that Rhoad's test is based on reaction to direct solar radiation.

Ragab, Ghany and Asker (66) studied the effect of shading, both indoors and outdoors, and sprinkling the water for three minutes and five minutes, on the heat tolerance of water buffalo and cattle of several breeds. From this study they conclude that shading proved the most favorable cooling treatment and that shading outdoors was better than indoors. Sprinkling, though giving excellent results, did not pay and was judged to be impractical under farm conditions. Buffaloes were the most sensitive to direct solar radiation and likewise were more sensitive to shading and sprinkling.

Minett (56) studied the effect of showers, rain and wallowing on the body temperature of water buffalo. Wallowing in a tank of water for 20 minutes gave similar results to wallowing for one hour. Hosing for 3 minutes was as effective as wallowing for 20 minutes. Natural rain showers was most effective in reducing body temperature. He concludes that a shower bath is practically as efficient, more hygienic, and no more costly than a properly constructed wallow for commercial dairies.

Sinha and Minett (78) found cooling off the water buffalo by water splashed on the animals during the hot months resulted in increased milk production. This was mostly the result of increased production in the afternoon milking. Milk yield decreases and becomes irregular when the buffalo cows are not splached with water during the hot days.

Studies on the seasonal variations of body temperature, respiration rate, and pulse rate indicate that the buffalo has the lowest body temperature, and the lowest pulse and perspiration rate of all the breeds studied. (Badreldin et al (15)). This generally lower physiological function is characteristic of the species. It is also a typical species trait of the buffalo to react more to higher temperatures and to solar radiation. The buffalo by nature, tends to desire to wallow more during hot weather. Sinha and Minett observed the frequency of desire to wallow and found that the frequency was very high from July to October and strong from May to July. There was little tendency to desire to wallow during the cooler months.

In summary, the water buffalo, being a semi-aquatic animal, is not by nature designed to be able to withstand long periods of solar radiation. Tests of heat tolerance substantiate the findings of histologic examination of the skin of the water buffalo. Heat tolerance tests as proposed by Rhoad are not applicable to the water buffalo. The water buffalo is a tropical and semi-tropical animal that is capable of high heat tolerance if husbandry practices place it in as close to its native environment as possible. The suggestion that large dairies use showers to assist in maintaining heat equilibrium in the buffalo has much to be said in favor of it.

Chapter XII. Economic Evaluation

1. Economic Evaluation

The economy of milk production of the water buffalo has not been reported in the English literature. Khishin (49(does deal with the economy of production in his Arabic textbook on animal breeding. Since this is the only reference available, the writer had the tables and explanation translated. The prices are pre-World War II prices and although all prices have risen since the end of the war, the prices are still relative. In general, if the prices used by Khishin were multiplied by 4, the result would be approximately today's prices.

Khishin assumes a herd of 100 buffalo cows, 4 bulls and 70 head of young stock coming on. The age of the cows be expresses as the number of calves they have had. His herd then is made up as follows:

20 head of cows with their 5th calf
20 head of cows with their 4th calf
20 head of cows with their 3rd calf
20 head of cows with their 2nd calf
20 head of cows with their 1st calf
20 head of 2 year olds-bred heifers
25 head of yearling heifers
25 head of heifer calves
4 mature bulls

TOTAL INVESTMENT IN ANIMALS L.E. 3000

The feed, costs and returns were then calculated as follows:

1) Feed for the 100 cows:

	L.E.
Berseem - 66 acres @ L.E. 8. per acre	528.000
Corn fodder - 350 tons @ L.E. 0.270 per ton	143.100
Horse beans - 122 Ardebs @ L.E. 1.250	152.500
Corn - 68 ardebs @ L.E. 0.600	40.800
Cottonseed cake - 15 tons @ L.E. 3.50	52.500
Straw - 340 loads @ L.E. 0.050 per load	17,000
SUB-TOTAL	933.900

2) Feed costs for young stock and bulls:

	L.E.
Feed costs to weaning time	337.500
Cost of feed for 25 calves weaning to 1 year	70.250
Cost of feed for 25 yearling heifers	123.500
Cost of feed for 20 two-year olds	148.000
Cost of feed for 4 bulls	40.000
SUB-TOTAL	719.250

3) Expenses for labor and miscellaneous costs:

	L.E.
Labor-caring for 100 cows - 7 men @ 12.	84.000
Feeders for 100 cows - 2 men @ 12	24.000
Milkers - 8 men @ 18.	144.000
Calf tenders for 4 months 3 men @ 4	12.000
Men to tend bulls - 3 men @ 12	36.000
Depreciation of tools, stables, etc.	75.000
Transportation of milk - 2 trucks	200.000
Veterinary treatment and losses	50.000
Interest on capital - 3% interest	90.000
SUB-TOTAL	715.000

TOTAL EXPENSES L.E.2368.150

RETURNS:

	L.E.
Milk from 90 cows 3200 lbs. @ .009	1728.000
Manure - 3 cubic meters per cow	200.000
Calves for sale at weaning 65 head @ 5.	325.000
5 head of two year old heifers @ 14.	70.000
20 head of old cows @ 9.00	180.000
Increase in value of inventory - 70 head @ 6.00 per head	420.000
TOTAL RETURNS L.E.	2923.000
LESS TOTAL COSTS	2368.150
PROFIT L.E.	554.850

Chapter XIII Review of the Present Situation

From the above survey of present knowledge, it is obvious that there is much to be done in research on fertility of the water buffalo. In spite of gaps in the present knowledge and in a few cases contradictory results, it is possible to develop a program of improvement for these fertility characteristics.

More information is needed on age at puberty. It would seem that age at puberty might be heritable but it is probably affected by nutritional level of the female. The growth curves of Egyptian buffalo indicate that up to 6 months of age, the growth is normal and comparable with that of the Italian buffalo. During the critical period from 6 months to 24 months growth is definitely inhibited by the nutrition available in Egypt. Just how much this would affect age at puberty is problematical but retarding of growth is apt to delay to some extent the physiological function of onset of puberty. Research is needed to tie down the effect of heredity and nutrition in their effect on age at puberty.

The length of oestrous cycle is fairly well established and excellent work by Hafez and his co-workers has been done. Silent heat is a big problem. Its causes and if possible methods of prevention must be established by research work. Also, a great deal of research work is needed to establish the causes of other abnormalities in the physiology of reproduction in the water buffalo female. The estrogen level in the buffalo cow is low and failure of function of the corpus luteum if pregnancy has resulted in foetal mortality. The relationship between ovarian function, estrogen level and silent heat, foetal mortality and breeding failures must be established. The whole problem of ovarian function needs considerable research work before definite recommendations can be made.

The length of gestation period and causes of variation in length are fairly well established in spite of some conflicting reports. Further research work is not needed.

Age at first calving is determined by age at puberty, age at breeding, and length of gestation period. Research on age at puberty will do much to correct as far as possible the age at first calving. Management of the herd plays a large part in age at first calving. However, it is not likely that age at first calving can be materially reduced below 36 months of age.

There are some conflicting reports on the various influences affecting calving interval. Repeatability estimates vary from 0.05 to 0.28. However, the majority of the reports show a low value for repeatability of calving interval. The writer is inclined to accept the lower values as being true. If this be true, then calving interval is not a permanent characteristic of the individual cow but is due to influences of environment, management, and nutrition of the female. Evidence presented by Ashfaq and Mason definitely shows that

calving interval may be reduced by better management practices. Their outstanding accomplishment of reducing calving interval from 614 days to 385 days in five years demonstrates what can be accomplished by proper herd management. The work of Hafez showing that post-partum oestrous occurred 44 days after calving and that conception took place 81 days after calving, certainly substantiates the results of Ashfaq and Mason. A calving interval of 385 days is possible in any herd.

In general, heredity has not been shown so far to be a major factor in the fertility record of the water buffalo. Husbandry practices have been shown to be a major factor in a few instances. The improvement of husbandry practices is usually most difficult, for the research or extension worker is dealing with the human problem and not with the animal population. Age old beliefs and superstitions are difficult to overcome in any country in the World. Most husbandry practices are based on knowledge, right or wrong, passed on from father to son. The problem is not insurmountable, however,

The survey of milk production of the water buffalo is fairly complete and little research is needed to complete the entire picture. Application of proven principles of livestock improvement are needed, however. An international milk production recording organization would be a start in locating superior milk production qualities. Its value, however, would not be as great as the DHIA in the United States simply because husbandry practices are much more variable and these largely influence milk production.

Repeatability and heritability estimates are approximately the same as those observed in dairy cattle. Repeatability estimates definitely indicate that total milk production is a characteristic of the cow. The heritability estimates indicate that selection methods used in dairy cattle are equally applicable to the water buffalo.

Repeatability of butter-fat production is slightly higher than that of most reports on milk production but the difference is of little significance. Data on butter-fat yields are scarce and research workers have done little butter-fat testing in spite of the fact that butter-fat is the most important product of the water buffalo. In many cases, this lack of data is due to lack of facilities to do butter-fat testing. Heritability estimates, or data that could be used for making estimates, are not available. It is reasonable to assume that heritability is close to that of milk production. More data on total butter-fat production are needed as well as data on other components of milk as total solids, solids not fat, etc. so that the genetics of these characteristics may be studied. Repeatability of total solids not fat, for example, on a group of water buffalo cows from Maghrabi's data was found to be 0.51. This indicates a wide variation between cows and that this component of the milk is also an individual characteristic of the cow.

Mortality rate as reported for calves is extremely high, much higher than probably exists on the farms of Egypt. This is due to crowded conditions at the experiment stations and not due to any inherent lack of vitality in the water buffalo. Under farm conditions, it is doubted if mortality rate is more than 10 percent up to 3 years of age. The buffalo, however, seems to be susceptible to enteritis, much more so than Egyptian cattle raised under the same conditions. This is shown by both the studies by Asker and El Itriby and by Reda and Oloufa. Enteritis attacks all age groups and is responsible for most of the death observed. The Egyptian water buffalo seems immune to cattle plague and to Texas fever, and is not highly susceptible to tuberculosis. Since cattle plague is common in Egypt, the Government of Egypt has taken the policy of not allowing imports of other water buffalo into Egypt. This seems justified since other strains of water buffalo in other countries are not immune to these diseases. This is a valuable inherited characteristic.

The studies on growth are so limited that nothing is known on the genetic and environmental aspects of growth in water buffalo. The same might be said also of meat and veal production in the water buffalo.

The research work on skin structure and heat tolerance is outstanding both from a theoretical and practical viewpoint. The work by Hafez on skin structure explains fully the results obtained on heat tolerance tests. That the water buffalo is heat tolerant under the conditions of semi-aquatic life, cannot be denied. Husbandry practices, therefore, can be adopted that will allow the water buffalo as near as possible the type of existence for which it was designed. Such has been the case with swine, another domesticated semi-aquatic animal. Swine, today, in America are raised under sanitary conditions and with some modifications, the husbandry practices of the water buffalo can be adapted to fit their needs.

The problems briefly at the present time are:

1. Lack of organized improvement programs to develop the water buffalo for milk, meat, or work. There is a need for a DHIA for water buffaloes.

2. The entire physiology of the water buffalo needs added information, especially as related to endocrinology of the buffalo. The apparent low endocrine function of the ovaries of water buffalo cows leads one to believe that other endocrine glands are involved.

3. As indicated above, milk and butter-fat records are lacking and record keeping should be encouraged even down to the farm level. The one-day-a-month system used by DHIA in the U.S. could be used to greatly expand the records kept to date.

4. Data are lacking on growth of water buffalo. Reports to date are meager. The relationship between early growths and age at puberty should also be studied.

5. There is a real lack of data on meat quality and production. Such data can be obtained from many sources and should be available now.

6. There are no data available nor measures designed for draft qualities. That the water buffalo is strong cannot be denied but how strong and endurance of strength needs study.

7. Data are limited on disease resistance and susceptability.

8. Basic research is needed on nutrition including basal metabolism, metabolic rate, digestability and nutritive requirments.

9. Little results are reported on management of water buffalo. More information is needed in all phases of management.

10. Basic studies on economic evaluation of this animal are needed.

BIBLIOGRAPHY

1. Ahmed, I. A. and A. O. Tantowy 1954 Growth in Egyptian Cattle during the first Two Years of Age. Alex Jour. Agr. Res. 2:1 - 11.

2. Alim, K. A. and I. A. Ahmed 1954. Month of Calving Age at First Calving, and Calving Interval of the Buffaloes in a Dairy Herd in Egypt. Emp. Jour. Expt. Agric. 22:37-41.

3. Asdell, S. A. 1946 Patterns of Mammalian Reproduction. Comstock, N. Y. 437p. Illus.

4. Ashfaq, M. and I. L. Mason 1954. Environmental and Genetical Effects on Milk Yield in Pakistani Buffalo. Emp Jour Expt Agric 22:161-175.

5. Asker, A. A. and M. T. Ragab. 1951. The Generation Interval in Egyptian Livestock. Cairo Univ. Bull. No. 4, 24pp, Illus.

6. Asker, A. A., M. A. Ghany, and M. T. Ragab. 1952 Effects of Exposing Cattle and Buffaloes to Sun during Summer in Egypt. Ind. Jour. Dairy Sci. 5:171-184.

7. Asker, A. A. and M. T. Ragab. 1952. Causes of Variation in Birth Weight of Egyptian Cattle and Buffaloes. Indian Jour. Vet. Sci. and An. Husb. 22:265-272.

8. Asker, A. A., M.T. Ragab, S. S. Khishin, and A. S. Sheikh 1952. A Study of Some Body Measurements in Egyptian Buffalo and their Relation to Milk Yield. Cairo Univ. Bull. No. 13, 13pp.

9. Asker, A. A., M. T. Ragab, and M. A. Ghany. 1953 Repeatability and Heritability of Some Characters in Egyptian Buffaloes. Indian Jour. Dairy Sci 6:61-65.

10. Asker, A. A., M. T. Ragab, and M. A. Ghany. 1953 Some Factors Affecting Heat Tolerance of Cattle and Buffaloes. Nature 171:1074-1075.

11. Asker, A. A., M. T. Ragab, and S. A. Hilmy 1954 Longevity in Egyptian Cattle and Buffaloes Ind. Jour. Dairy Sci 7:135-138.

12. Asker, A. A., M. T. Ragab, and T. H. Kamal 1954 The Effect of Feeding Thyroprotein on the Composition of Milk of Egyptian Buffaloes. Ind. Jour. Dairy Sci 7:36-39.

13. Asker, A. A., M. T. Ragab, and S. A. Hilmy 1955 Genetic Improvement in Milk Yield in Two Herds of Cattle and Buffaloes in Egypt. Ind. Jour. Dairy Sci. 8:39-46.

14. Asker, A. A., and A. A. El Itriby 1956 Calf Mortality, Abortion, Twinning, and Sex Ratio in the Egyptian Buffaloes. (To be published).

15. Badreldin, A. L., Mohammad M. Oloufa, A. A. Asker, and M. A. Ghany 1951 Effect of Seasonal Variation on Body Temperature, Respiration Rate, and Pulse Rate of Cattle and Buffaloes. Cairo Univ. Bull.No. 4, 30pp

16. Badreldin, A. L. 1953 Frequency of Successful Conception under free mating conditions in the Egyptian Buffaloes. Experimentia 8:391-392.

17. Badreldin, A. L. and M. A. Ghany 1954. Species and Breed Differences in the Thermal Reaction Mechanism. Journal Agricultural Science 44: 160-164.

18. Badreldin, A. L. 1955. Dressing out Precentage in Suckling Buffalo Veals. Indian Jour. Vet. Science and An. Husb. 25:61-64.

19. Balcita, Alvaro N. G. V. Garcia, Lolita Austria, L. A. Ynalvez, and J. K. Loosli 1954. Carotine, Vitamin A, Calcium, and Inorganic Phosphous Content of the Blood Plasma of Cattle and Carabaos. Philipp. Agric. 38:388-391

20. Dharamarajan, G. S., R. Venkateswara, M. N. Menon, and Noshir N. Dastur 1950. Composition of Milk of Indian Animals. 1. Freezing Point, Lactose, Chloride, and Acidity in the Milk of Different Breeds of Animals. Indian Jour. Vet. Science and An. Husb. 20:35-46.

21. Dutt, M. K. and P. Bhattacharya 1952. Chromosomes of the Indian Water Buffalo. Nature 170:1129-1130.

22. El-Attar, Tawfik 1955. Excretion of Urinary Estrogens during Pregnancy in the Egyptian Buffalo. Thesis; Cairo University.

23. El-Itriby, A. A. and A. A. Asker 1956. Buffalo Bulls in Egypt. (To be published)

24. El-Itriby, A. A. and A. A. Asker 1956. Repeatability and Heritability of Some Dairy Characters in Cattle and Buffaloes in Egypt. (to be published)

25. Garsula, Alexander A. 1954. The Consumption of Salt by Carabaos. Phillip Agric. 37:485-491.

26. Ghanem, Y. S., A. Abdul-Fadl, A. Zaher, and F. A. Soliman 1955. Environmental Causes of Variation in the Length of Gestation of Buffaloes. Ind. Jour. Vet. Sci. and An Husb. 25:301-306.

27. Ghanem, Y. S., A. Zaher, A. Abdel-Fadi and F. A. Soliman 1955. Genetic Causes of Variation in the Length of Gestation of Buffaloes. Ind. Jour. Vet. Sci. and An. Husb. 25:307-311.

28. Hafez, E. S. E. 1952. The Buffalo A Review. Indian Jour. Vet. Science and An. Husb. 22:257-263.

29. Hafez, E. S. E. 1952. Conception Rate and Periodocity in the Buffalo. Emp. Jour. Exper. Agric. 21:15-21.

30. Hafez, E. S. E. Conception Rate in the Buffalo 2nd Int. Cong. Phys. Path 97-100

31. Hafez, Saad 1953. Patterns of Mating Behavior in the Domestic Buffalo. Acta Zoologica 34:233-239.

32. Hafez, E. S. E. 1953. Gonadtrophin - Induced Ovulations in the Buffalo. Vet. Rec. 65:384.

33. Hafez, E. Saad, E. 1953. Patterns of Mating Behavior in the Domestic Buffalo. Acta Zool 34:233-239

34. Hafez, E. S. E. 1954. Oestrous and Some Related Phenomena in the Buffalo. Jour of Agricultural Science 44:165-172.

35. Hafez, E. S. E. 1954. Foetal Atrophy in the Buffalo. The Vetinerary Record 66:264-268.

36. Hafez, E. S. E. 1954. Infertility in Buffalo Cows. Fert. & Sterel. 5:482-491.

37. Hafez, E. Saad E. 1954. The Placentome in the Buffalo. Acta Zool 35:177-191.

38. Hafez, E. S. E., and M. M. Shafei 1954. Sweating Mechanism in the Domestic Buffalo Nature 174:1181-1184.

39. Hafez, E. S. E. and A. Anwar 1954. Normal Haematological Values in the Buffalo. Nature 174:611-612.

40. Hafez, E. S. E. 1955. Puberty in the Buffalo Cow. Jour. of Agric. Science 46:134-142.

41. Hafez, E. S. E., A. L. Badreldin, and M. M. Shafei 1955. Skin Structure of Egyptian Buffaloes and Cattle with Particular Reference to Sweat Glands. Jour. Agr. Sci. 46:19-30 illus.

42. Hafez, E. S. E., A. L. Badreldin and M. M. Shafei. The Hair Coat in Bovinae. Emp. Jour. Exp. Agr. 23:34-38 illus.

43. Hafez, E. S. E. 1955. Factal - Maternal Attachments in Buffalo and Camel. Indian Jour. Vet. Science and An. Husb. 25:109-115.

44. Hafez, E. S. E. and Y. H. Darwish 1956. Effect of Successive Ejaculations on Semen Characteristics in the Buffalo. Jour. Agr. Science 47:191-195.

45. Hassan, Aly H. 1944. The Composition of Milk of Cows and Buffaloes. Thesis - Cairo University.

46. Ismail, A. A. and A. M. El Naegoumi 1955. Studies on the Compositional Quality of the Milk of Egyptian Buffaloes and Cows in Relation to the Major Nitrogen Constituents. Alex. Jour. of Agr. Res. Vol. 3 No. 1. p 10-23.

47. Kamal, Taymour Hussein 1956. The Effects of Stage Lactation, Season of Calving, and Age of Buffaloes on the Yield and Composition of Milk. Thesis for M. S. Cairo University.

48. Kehar, N. D. and V. N. Murty 1951. Physiological Studies on the Blood of Domestic Animals II Male Buffaloes. Indian Jour. Vet. Science and An. Husb. 21:13-16.

49. Khishin, A. F. 1948. Animal Breeding. 619 p Illus. Cairo (translated Title - in Arabic).

50. Khishin, S. A. 1951. Studies on the Egyptian Buffalo 1. Average Age and Calving Interval. Emp. Jour. Exp. Agri. 19:185-190.

51. Knapp, Bradford Jr., A. L. Baker, J. R. Quesenberry and R. T. Clark 1941. Growth and Production Factors in Range Cattle. Mont. Agri. Expt. Sta. Bull. 400, 13pp.

52. Knapp, Bradford Jr., W. V. Lambert and W. H. Black 1940. Factors influencing Length of Gestation Period and Birth Weight in Cattle. Jour. Agric. Res. 61:277-285.

53. MacGregor, R. 1941. The Domestic Buffalo. Vet. Record 53:443-450.

54. Maghrabi, M. E. 1946. Egyptian Buffaloes Milk, Thesis, Cairo University.

55. Maymone, B. 1942. Die Buffelzucht in Italien Zeitschrift Fur Tierzucht Und Zuchtung-sbiologie Band 52, Heft 1.

56. Minett, F. C. 1947. Effects of Artificial Showers, Natural Rain, and Wallowing on the Body Temperatures of Animals. Jour. Am. Sci 6:35-49.

57. Negoumi, A. M. 1954. Some Factors Affecting the Concentration of Citric Acid in the Milk of Egyptian Buffaloes and Cows. Alex Jour. Agri. Res. 2:70-82.

58 Ocampo, Antonio R. 1939. Further Studies on the Breeding Habits of the Carabao. Philip.. Agric. 28:286-307.

59. Oloufa, M. M., A. L. Badreldin and M. Sharaf El Din 1954. Feeding Thyroprotein to Egyptian Buffaloes. Cairo Univ. Bull. No. 31, 9 pp.

60. Olver, Sir Arthur 1938. A Brief Survey of Some Important Breeds of Cattle in India. Misc. Bull. No. 17 Imp. Coun. of Agr. Res. 45 pp Illus.

61. Perry, Enos J. 4-H Dairy Handbook. N. J. Ext. Service Bulletin.

62. Phillips, Ralph W. 1949. Breeding Livestock Adapted to Unfavorable Environments. FAO Agr. Studies No. 1, 181 pp illus. Wash. D. C.

63. Prabhu, S. S. and P. Battacharya 1951. Comparison of First and Second Ejaculates Collected in Rapid Succession from the Indian Water Buffalo. Indian Jour. Vet. Sci. and An. Husb. 21:257-262.

64. Ragab, M. T. 1945. A Study of the Shape of the Lactation Curve in Egyptian Cattle and Buffaloes. Thesis Cairo University 39 pp

65. Ragab, M. T. and A. A. Asker 1954. Factors Influencing Length of Gestation Period in Egyptian Cattle and Buffaloes. Indian Jour. of Dairy Sci. 4:159-169

66. Ragab, M. T. Ghazy and A. A. Asker 1953. Effect of Shading and Sprinkling on Cattle and Buffaloes in Egypt. Indian Jour. Vet. Sci. and An. Husb. 23:205-215.

67. Ragab, M. T., A. A. Asker and M. S. Ghazy 1953. Effect of Age on Total Milk Yield and Length of Lactation Period in the Egyptian Buffalo. Indian Jour. Dairy Sci. 6:181-188.

68. Ragab, M. T., A. A. Asker and M. S. Ghazy 1954. Effect of Season of Calving Dry Period and Calving Interval on Milk Yield and Lactation Period of Egyptian Buffaloes. Indian Jour. Dairy Sci 7:8-18.

69. Ragab, M. T., A. A. Asker and S. A. Helmy 1956. The Relation Between Some Fertility Aspects and the Milk Yield in Egyptian Cattle and Buffaloes. (in manuscript)

70. Reda, H. and M. M. Oloufa 1954. Incidences of Diseases and Mortality Among Egyptian Cattle and Buffaloes. Brit. Vet. Jour. 110:157.

71. Reyes, Fidel F. 1948. The Growth and Development of Philippine and Murrah Carabaos and their Crossbreed. Philippine Agric. 31:271-278.

72. Rhoad, A. O. 1938. Some Observations of the Response of Purebred Bostaurus and Bos indicus cattle and their Crossbred Types to Certain Conditions of Environment. Proc. Am. Soc. An. Prod. 1938, pp 284-295.

73. Ricerra, Fernano C. 1940. Observations on the Capacity and Measurements of the Alimentary Tract of Native Carabaos. Philip. Agric. 28:771-778.

74. Shukla, D. D. and P. Battacharya 1949. Studies on the Semen Characteristics of Indian Breeds of Livestock. Indian Jour. Vet. Sci. & An. Husb. 19:161-170.

75. Smith, W. Journal of Central Bureau for An. Husb. and Dairying 1:153-162 Vol. 1. 1928

76. Sidky, Dr. A. R. 1951. The Buffalo of Egypt. 1, General Study and Improvement Work. 19 pp illus. Cairo.

77. Sidky, A. R. 1951. The Buffalo of Egypt II Breeding Efficiency in the Egyptian Buffalo (A) Age at First Calving. 9 pp Illus. Cairo.

78. Sinha, K. C. and F. C. Minett 1947. Application of Water to the Body Surface of Water Buffaloes and Its Effect on Milk Yield. Jour. An. Sci. 6:258-264.

79. Tantawy, A. O. and I. A. Ahmed 1953. Some Facotrs Influencing Birth Weight in Egyptian Cattle. Alex. Jour. of Agr. Res. Vol. I, No. 1.

80. Villegas, Valente 1929. The Trend of Sexual and Reproductive Seasons among Horses, Cattle, Water Buffaloes, Sheep, and Goats under Los Banos Conditions. Philip. Agric. 17:477-486.

81. Villegas, Valente 1930. Observations on the Breeding Activities of Carabaos. Philip. Agric. 19:3-9.

82. Villegas, Valente 1939. The Birth Weights of Horses Cattle and Carabaos and their Relation to the Weights of Dam. Philip. Agric. 28:253-259.

83. Youssif, M. S. Saleh 1956. A Study of the Carotenoid, Vitamin A, and Riboflavin Content of Buffaloes' and Cows' Milk and Colostrum. Thesis, Cairo University.