Reproductive performance of the one-humped camel. The empirical base

R. T. Wilson [1]

WILSON (R. T.). Performances de reproduction du dromadaire. Base empirique. *Revue Élev. Méd. vét. Pays trop.*, 1989, **42** (1) : 117-125.

Cet article est une synthèse des données empiriques et des observations provenant la plupart d'études de terrain sur les performances de reproduction du dromadaire. Des références sont faites à de nombreux pays d'Afrique et d'Asie. L'âge élevé à la première parturition (60 mois), le long intervalle entre les mises bas (24 mois et plus) et la réforme relativement précoce des reproductrices (à partir de 10 ans) sont responsables du faible nombre de jeunes, en moyenne moins de 3, par carrière de reproductrice. Le dromadaire présente un cycle de reproduction fortement influencé par la saison dans la plupart des régions mais les raisons en sont encore mal connues. Les performances de reproduction peuvent être accrues en réduisant en même temps l'âge à la première parturition et l'intervalle de mise bas, et en augmentant la durée de reproduction de la femelle. *Mots clés* : Dromadaire - *Camelus dromedarius* - Reproduction - Parturition - Age - Longévité - Influence de la saison - Afrique - Asie.

INTRODUCTION

Until recently it has been considered that scientific knowledge of the one-humped camel has been fragmentary, that little research had been undertaken, and that there were very few publications relating to it. A changed attitude has been forced on the research community by the appearance of a number of bibliographies during the early part of the current decade (10, 15, 32, 50). These lists of references contained approximately 3,000 items up to 1980. Since then, approximately 900 additional scientific articles have been published on *Camelus dromedarius* (45).

An analysis of the published material (46) for both the pre-1980 and post-1980 periods showed great imbalances in input in the most important fields of research. In the pre-1980 period most research effort was devoted to diseases and veterinary aspects (approximately 640 references) and to non-reproductive physiology (560 references). Reproduction, as such, mustered about 240 references but these, almost without exception, concentrated on the physiology of reproduction. Of 412 listed papers for 1981 to 1985 inclusive, about 140 covered diseases and veterinary aspects, 65 were on anatomy and morphology, 50 looked at non-reproductive physiology and less than 40 covered the reproductive processes, with most of these last again concentrating on physiology.

Two recent reviews have covered reproduction in the male and in the female dromedary. The paper on the male animal (40) devotes less than 300 words to « Puberty and Breeding Season » in which it is stated that « It is well known that mature male camels show seasonal sexual activity referred to as the rut » : a further 350 words are devoted to « Sexual Behavior ». The remainder of the male paper deals with anatomy, histology, physiology and the pathology of the genital organs. The paper on the female camel (11) commences its abstract by stating « The breeding season in the camel appears to be longer than was previously thought ». It then devotes a similar amount of space to puberty, the breeding season, age at first calving, calving interval and reproductive performance as does the paper on the male.

The conclusions to be drawn are that, although there is now a very good background of information on the one-humped camel, much of it has concentrated on the « easy » aspects of research which can be carried out in the comfort of a laboratory and the relative comfort of an abattoir. The « difficult » aspects - the long-term methodical effort required, because of the extended production cycle of the camel, under arduous conditions - have still to be fully elucidated.

This paper attempts to present the field data available on the reproductive performance of the one-humped camel. It is based in part on the author's own work and in part on an analysis of the still sparse literature on the camel's reproductive performance in the field.

AGE AT FIRST PARTURITION

Physiological studies have shown that puberty can occur in the female camel at an age of two years (2, 3) in Saudi Arabia and at eight to twelve months in southern USSR (1). Estimates of puberty in traditio-

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nally managed camels in Somalia varied from four to six years and age of « sexual maturity » from five to seven years (28).

In spite of the early age at which puberty can occur, most camels do not give birth to their first offspring before they are four years old. In India and in Somalia first parturition has been said to be at four years (19, 23).

Data from retrospective surveys using some form of questionnaire to establish the reproductive careers of female camels have provided reasonably firm indications of ages at first parturition. In traditionally managed herds in Kenya, an age of 58 months has been estimated (16). Although there was no evidence to support such a conclusion, it was thought that an increased growth rate from veterinary inputs might lead to an earlier age at first calving (38). Two different retrospective studies from Niger provide estimates of 63.4 months (5.28 years) on a sample of 2,610 camels (29) and 58.8 months (4.9 years) with a standard deviation of 19.2 months for 215 females (43). In the former of these Niger studies (29) between 3 and 80 per cent of females (varying with ethnic group and management type) first gave birth between four and five years. About 95 per cent of camels had given birth for the first time on reaching six years, except in one transhumant group where a 95 per cent level of camels having given birth at least once was not reached until the 8-9 year age group. In the latter Niger study (43) the range of age at first parturition varied between two and eleven years.

Animals of absolute known age gave birth for the first time at 61 months in an experimental herd in Kenya (16). In ranch herds in Kenya the average age at first parturition of 37 camels which had run freely with a male from birth was 54.2 ± 2.8 months (44). The age at first parturition varied among ranches from 48.6 ± 2.8 to 56.1 ± 56.1 months, the differences not being significant. The youngest animal first gave birth at 45.6 months and the oldest at 71.3 months on these Kenya ranches.

The average age at first parturition of 105 Bikaneri camels (5) on a breeding farm in Rajasthan was 61.0 ± 0.98 months (1,838 ± 29.7 days) but it is not clear if there was control of the age at which females were put to males. There was a significant reduction in age at first birth for camels which were born in the periods 1960-1964 (65.2 months), through 1965-1969 (61.0 months), to 1970-1974 (56.8 months). There were no significant differences due to the month of birth of the dam. This Bikaneri study provides the only known estimate of heritability of age at first parturition in camels, this being very low at 0.03 ± 0.40.

NUMBER OF YOUNG PER PARTURITION

In camels a single young at birth is the norm. Twin births have not been recorded in any study and only in very rare cases have twin foetuses been recorded : two cases in 494 pregnancies (0.4 per cent) in Sudan (26) and one case of twins and one case of triplets in 785 cases in Egypt (36).

Cases of multiple ovulations are not, however, uncommon. Several studies indicate about 12 to 14 per cent of double ovulations and 1 to 2 per cent of triple or more (12, 17, 26, 36). One report provides a figure of 18.6 per cent double ovulations (14).

INTERVALS BETWEEN BIRTHS

The conventional wisdom is that the interval between successive births in one-humped camels is about two years. Few detailed studies have been undertaken. Retrospective studies in traditional systems tend to confirm that a camel gives birth once every two years but intervals vary and are often spread over a very long period. In Mali, of 43 cases reported in a Touareg herd, nine intervals were between 13 and 15 months, twelve between 16 and 19 months, nineteen of about 24 months and three of longer than 24 months (39). An early study in Kenya (7) showed that of 26 intervals only four were of less than 24 months, fourteen were of about 24 months and eight were 25 months or longer. In Kenya an interval of 26.8 months in traditional herds was reduced to 20.8 months when a veterinary package was implemented (38). This veterinary treatment comprised : routine treatment of tick and worm infestations ; vaccination against anthrax and blackquarter ; treatment of trypanosomosis and other diseases ; and a regular supplement of salt. A second traditional herd in Kenya showed an interval of 28.4 months (35).

In Niger the average interval between births in three eastern provinces was 30 months with variations between sedentary herds (25 months in Maradi, 27 months in Zinder, 38 months in Diffa) and transhumant herds (24 months in Maradi, 30 months in Zinder, 27 months in Diffa) (33). Farther north in the Aïr region of Niger, in a Touareg traditional system, an interval of 26.2 ± 10.56 months was established for a total of 329 intervals (43). The frequency distribution of all these intervals within three-monthly periods is shown in figure 1. The interval varied among different parities, there being a general reduction between successive

TABLE I Effects of parity on birth intervals (months) of camels in a traditional pastoral system in Niger and a modern ranching system in Kenya.

Interval	Niger			Kenya		
	n	$\bar{x}$	s.d.	n	x	s.d.
1-2	144	28.6	9.10	190	19.3	0.48
2-3	97	24.0	9.63	149	18.3	0.51
3-4	54	25.8	8.89	77	18.8	0.66
>4	34	20.1	7.55	44	18.6	0.87

births (increasing parity) as the female progressed through her reproductive career (Table I).

Under commercial ranch management in Kenya where actual birth dates were recorded, the corrected least-squares mean of 460 intervals was 18.7 ± 0.38 months (44). Earlier estimates for these herds, based on fewer intervals and not taking into account abortions, were of about 21.6 months (35) this being very similar to the uncorrected mean of 20.2 months in the more complete study. In the more complete study (44), parity did not exert a significant influence on the interval although there did appear to be slightly shorter intervals in higher parities (Table I). There were significant effects of the female ($P < 0.05$), of the ranch ($P < 0.01$) and of the survival of young ($P < 0.001$) on the interval but not ($P > 0.05$) of the month of the previous parturition. An abortion or the death of the young before weaning led to a shorter interval to the next birth than if the young survived to weaning, probably due to the effects of lactation on the reproductive hormones. Intervals were clustered about 18 months, there being relatively few of longer than 30 months (Fig. 1).

In other controlled studies the interval between births has been established as 14.3 months (434 days) in Najdi camels in Saudi Arabia (4) and it has also been said that in commercial milk herds in the Al-Jouf region a calving interval of 14 to 15 months could be achieved (21). In Israel it has been said that birth intervals of less than one year can be obtained : an actual interval of 365 to 395 days (mean = 380) was demonstrated on a very small number of intervals after hormonal treatments had been used (51).

The short Israeli intervals were coupled with a reported gestation period of 345 to 360 days. All other recent studies report gestation periods longer than 360 days. In Kenya an average of 377 ± 12.1 days, in the range 360 to 411 days was recorded for 142 pregnancies (44). In Bikaneri camels average gestation length has been established as 391 ± 16.7 days (n = 296) in the range 325 to 444 days (37) and this period was not affected by parity or the sex of the calf. In other Bikaneri camels an even longer period of about 404 days was established for 56 gestations (30) with a

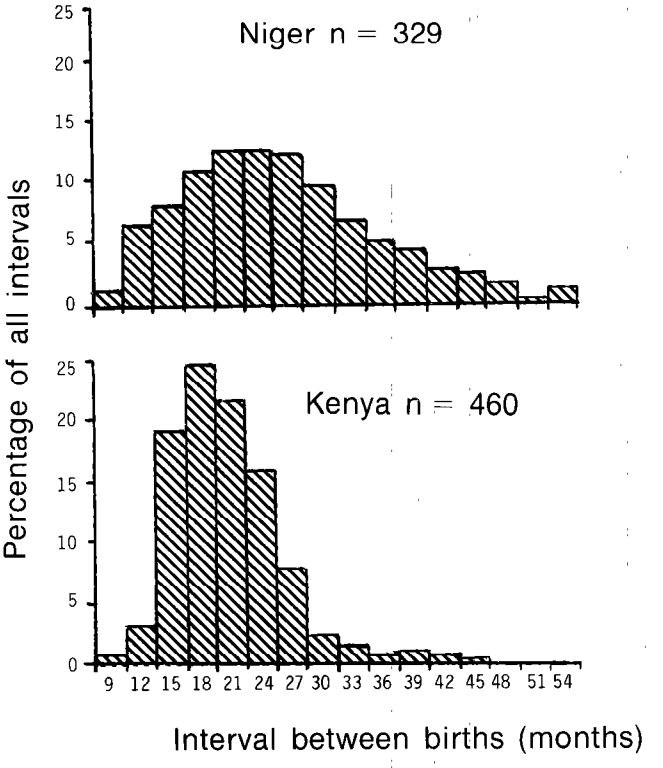

Fig. 1 : Distribution of birth intervals in camels in a traditional pastoral system in Niger and a modern ranching system in Kenya.

heritability of 0.016 ± 0.08, there being differences in gestation length due to sires ($P < 0.01$) but not to the sex of the calf.

FERTILITY

In this paper « fertility » is not used as a strictly terminological word. Expressions in the available literature are manifold and include calving percentage, reduplication rate, absolute fertility indices and age specific fertility rates. The annual reproductive rate

(ARR = number of young per birth x 365/parturition interval) has been used as a proxy for fertility in small ruminants (47, 48). The annual reproductive rate can be easily calculated and used for direct comparison of different studies. It has a slight disadvantage in that it assumes that all females of breeding age in the herd are in fact reproducing.

In northern Kenya calving percentages of 21.1 and 47.4 per cent have been quoted for « non-treatment » and « treatment » herds (38). Calculated from the calving interval provided, the ARR would be 0.45 and 0.58 young per female per year. On the same basis the ARR on commercial ranches in Kenya would be 0.64 (44).

In southern Somalia an absolute fertility index was calculated as the proportion of young under one year old to females of breeding age. In 1984 this was 0.78 (41) and does, in fact, approximate the ARR and also implies an interval between births of 15.4 months. For three Kenya populations, absolute fertility indices, using the same aerial survey methodology, of 0.90, 0.24 and 0.28 were calculated by the same author (31) : assuming that populations were of equal size, a composite absolute fertility index would be 0.47 with an implied birth interval of 25.5 months. In Darfur in western Sudan a calving percentage of 70 was estimated in 1977, an implied interval of 17.1 months (42). In retrospect, it seems probable that this reproductive rate in Darfur was due to rainfall fluctuations over the preceding years and probably represented a peak in productivity.

In Tunisia the reduplication rate varied from 30.8 per cent in 1971-1972 to 11.5 per cent in 1972-1973 in camels and average 63.6 per cent in the period 1969-1970 to 1972-1973 (8). In traditionally owned herds in the same Tunisian study the reduplication rate was 84.6 per cent in 1972-1973 but only 28.6 per cent in 1973-1974. The reduplication rate was calculated on the assumption that only half the females in a herd could be expected to give birth in any one year and therefore appears to be double the true calving rate. An approximate ARR for Tunisian army camels would be 0.32 and for the Tunisian traditional system it would be 0.28. In a more recent Tunisian study, 63.3 per cent of females were served by the bull and 54.4 per cent were fertile (20).

In northern Niger the ARR was calculated as 0.46 young per breeding female (43). In eastern Niger age specific fertility rates varied from 0.01 to 0.57 at different ages (29). Age specific fertility rates for each year group and a calculation based on 3-year moving average for the eastern Niger sample are shown in figure 2.

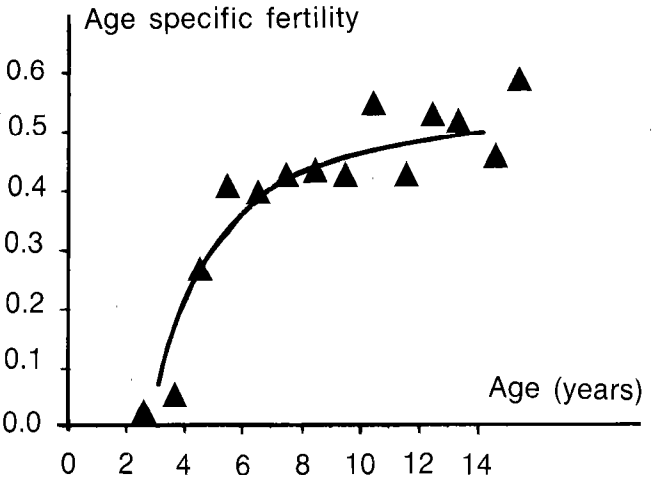

Fig. 2 : Age specific fertility for 2,756 camels in eastern Niger (based on data from Planchenault, 1984 (29)).

LONGEVITY AND LIFETIME PRODUCTION

If it is said that camels produce their first young at four to five years, it is also said that a female can breed up to 20 or even 30 years. Undoubtedly some animals will survive for 20 years but it will indeed be a rare one at 30 years. Most data on age is vague and possibly misleading. In some reports, ageing of camels is done in three simple classes of under one year, one to three years, and four years and over.

In southern Somalia camels were aged from aerial photographs by the length of their spine (41). Animals were grouped in classes of six months from 0 to 2 years old, in annual classes from 2 to 10 years, and in one class only of over 10 years. This last class comprised 14.9 per cent of the population of which 12.1 per cent were females. From the population structures established it was suggested that there had been low fertility about eight years previous to the survey.

Attempts to establish age pyramids in Niger showed population structures that were similar in both the north and in the east of the country. In the Aïr region the percentage of the population over 10 years was 15.4 per cent of which 12.0 per cent was female (49). In the three eastern regions of Maradi, Zinder and Diffa, an average of 18.0 per cent of six different types of herds was over 10 years old, 5.6 per cent being male and 12.4 per cent female ; between one-third and one-half of the females were usually in the age class of 10-

11 years (33).

In the Aïr it was considered that the break in the age pyramid at about 10 years could have been due to the effects of the 1968-1973 Sahel drought. The sharp reduction in numbers at about 10 years was also in good agreement, however, with the average lifetime production of young of breeding females (43). Reconstruction of breeding female careers showed that most females in the herd did not exceed four young (Fig. 3). A total of 215 camels had given birth to 573 young or an average of 2.7 per breeding female. Calculated from the age at first parturition and the average interval between parturitions, a female culled after 2.7 young would be aged about 10.8 years. In Kenya the average lifetime production of young was 3.5 per female on commercial ranches (44).

Similar calculations of average production of young were made in eastern Niger (33). In nine different types of herd the average age and productivity of a breeding female varied from 7.6 years and having given birth to 1.9 young to 8.6 years having produced a maximum of 2.4 young.

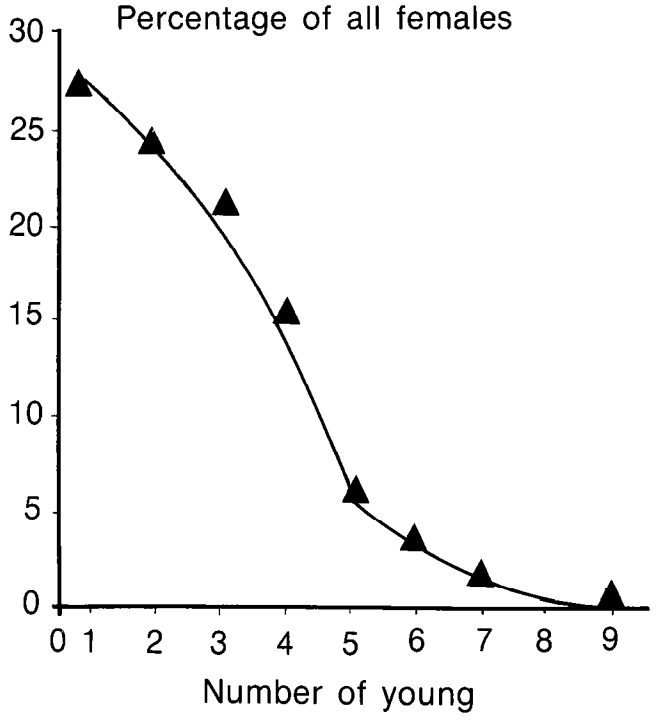

Fig. 3 : Percentage of females of breeding age and having had at least one parturition having given birth to a specified number of young.

SEASONALITY

The most commonly occurring phrase in articles dealing with the reproductive process of the camel is that the female is a seasonally polyoestrus animal. This is usually qualified by comments relating to the rutting season in the male and to the fact that the female is an induced and not a spontaneous ovulator.

Early empirical observations of the seasonality of breeding have been supplemented by abattoir studies and more recently by retrospective career histories and complete records. A summary of some of the literature data (Table II) indicates a marked seasonality

TABLE II Reported breeding seasons of the camel in different areas.

Country	Season	Reference
Pakistan	December-March	51
India	November-February	25
Somalia	April-May	24
Somalia	June + September-November	23
Egypt	December-April	36
Egypt	May-August	14
Sudan	March-August	28
Mali	February/March + August/September	39
Morocco	May-June	10

with most activity in winter in the northern hemisphere. Extended and irregular seasons are not uncommon, however, particularly when the camel is moved to areas outside its normal environment and range (Fig. 4). In zoo conditions in South Africa camels produced young in March, May, August, September and November (6). The author of the South African paper (6) considered that camels bred more or less regularly throughout the year and cited a similar situation at London zoo where young were born in February, April, September and December.

Various factors have been invoked as the trigger for the onset of the rut in the male and enhanced seasonal activity in the female. These include nutritional status, the photoperiod, and temperature and water relations. None provides an entirely satisfactory explanation as yet.

In Somalia there appear to be two main breeding seasons related to the bimodal rainfall pattern (22, 23) but births occur all year. In Djibouti, the little information available (18) also indicates opportunist breeding, perhaps related to the proximity of both the low and erratic rainfall on the Red Sea winter precipitation zone and of the inland and highland summer zone of Ethiopia.

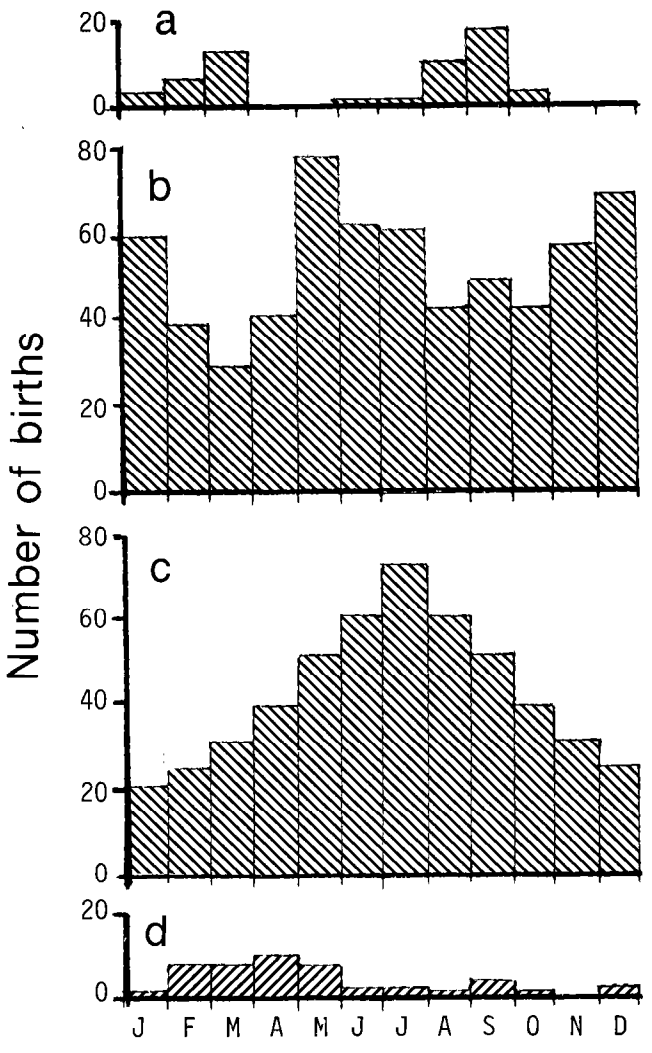

Fig. 4 : Distribution of births in camels in : a. Mali, n = 62, (39) ; b. Kenya, n = 636 (44) ; c. Niger, n = 520 (43) ; d. 11 European zoos, n = 47 (6).

In Kenya, in traditional herds there is some breeding all the year round (as indeed there usually is elsewhere) but with apparently greater activity in December/January and May (35) which may or may not have been associated with better nutritional status at conception. On Kenya commercial ranches, in spite of there being breeding all the year round, there were significant ($P < 0.001$) differences among months in the numbers of births with most taking place in May/June and November to January. A regression analysis on births and rainfall (as a proxy for primary productivity of vegetation) at each of 12 to 15 months earlier did not show any correlation between them (44).

In northern Niger there were also significant differences among months in the number of births but the pattern was more pronounced with a distinct peak in the short rainy season (43). The best correlations between assumed conception (12 months prior to parturition) and climatic variables were with minimum temperature, average temperature, maximum temperature and day length. Rainfall was again not significantly correlated with conception but it did improve the correlation when taken in conjunction with the minimum temperature.

CONCLUSION

The general statements that are usually made about the poor reproductive performance of camels appear to be confirmed by the empirical data and by field studies. Ages at first parturition are in general in the region of five years and these are not noticeably reduced even where feed conditions for rapid early weight gain are good. There are thus, for example, no apparent differences between the ages at first parturition under modern ranching and traditional extensive pastoral systems in Kenya. Puberty possibly occurs well in advance of first conception and research additional to that undertaken in Israel on hormone treatment needs to be carried out to determine the reasons for this.

The number of young per birth is almost always one. Multiple ovulations occur relatively frequently but it appears that only one egg is fertilized or there is very early embryonic death of a second foetus. It is probable that there is little advantage to be gained under normal conditions of camel husbandry in attempting to improve reproductive performance through multiple births.

Intervals between births are usually about or in excess of two years. In some areas and under some conditions of management, parturition intervals are of 18 months : it might be possible to reduce them even more using more intensive husbandry techniques and by the use of hormones. Whether it is desirable to devote scarce feed resources to intensive camel production, when cattle and small ruminant breeds can probably make better use of that feed, remains an open question. In addition, it is doubtful whether all or even many traditional communities would accept intervals shorter than 18 months in view of the fact that a major objective of their husbandry system is the provision of milk, particularly over the long dry seasons when other domestic species do not provide it.

Lifetime production is low, resulting from late ages at

first parturition, long intervals between births and a comparatively short reproductive life due to culling by owners from 10 years onwards. Reduced ages at first parturition, some shortening of birth intervals and a slightly increased age at culling could easily lead to another young per breeding female career.

The factors leading to the highly skewed seasonal distribution of births in most camel populations are not yet clear. Multi-site factorial experimentation, including nutritional and climatic studies and manipulation, are required in order to elucidate the mechanisms which govern seasonality.

WILSON (R. T.). Reproductive performance of the one-humped camel. The empirical base. *Revue Élev. Méd. vét. Pays trop.*, 1989, **42** (1) : 117-125.

This paper reviews data on the reproductive performance of camels mainly from field studies. A large number of countries from Asia and Africa are covered. Late ages at first parturition (60 months), long intervals between births (24 and more months) and relatively early culling of breeding females (from 10 years) are responsible for a total lifetime production of young of less than three per breeding female. Camels have a marked seasonality of breeding in most areas but the reasons for this are not yet clear. Reproductive performance can be increased by simultaneous improvements in age at first birth, shortened parturition intervals and greater longevity. *Key words* : Dromedary - *Camelus dromedarius* - Reproduction - Parturition - Age - Longevity - Seasonality - Africa - Asia.

WILSON (R. T.). Reproductividad del dromedario. Base empírica. *Revue Élev. Méd. vét. Pays trop.*, 1989, **42** (1) : 117-125.

Este artículo es una síntesis de los datos obtenidos principalmente a partir de estudios en el campo sobre la reproductividad del dromedario. Conciernen numerosos paises de Africa y de Asia. La edad elevada al primer parto (60 meses), el largo intervalo entre los partos (24 meses y más) y la eliminación relativamente precoz de vacas de vientre (a partir de 10 años) son responsables del número reducido de jovenes, menos de 3, por vida de vaca de vientre por término medio. El dromedario tiene un ciclo de reproducción muy influido por la estación en la mayoría de las regiones pero los motivos son todavía mal conocidos. La reproductividad puede acrecentarse al reducir, al mismo tiempo, la edad al primer parto, el intervalo de parto y al aumentar la duración de reproducción de la hembra. *Palabras claves* : Dromedario - *Camelus dromedarius* - Reproducción - Parto - Edad - Longevidad - Influencia de la estación - Africa - Asia.

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