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REALISM OF PHYSIOLOGICAL RESEARCH IN ANIMAL PRODUCTION IN SOUTH AFRICA

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"While pure science goes very deeply into a very limited problem – so that the definition of a scientist has become one who knows more and more about less and less, the function of applied science is to synthesize this detailed knowledge into a constructive whole, so that it can be used for a specific purpose."

Sir John Hammond, 1953

Any scientific investigation can be rendered realistic as far as pure science is concerned, but the realism of the outcome of such a research project, as far as its practicability is concerned, will depend entirely on the demands of the industry for such a new development. Therefore in order to evaluate the realism of research in animal production in South Africa it will be necessary to consider briefly our present situation and to make some projections into the future. Although forecasting of this nature may be without real merit unless reliable data are available, it is nevertheless necessary to look into the future if we are to make any serious effort to adjust our current work to meet the best interests of our communities.

Over the last three decades, South African farm animal numbers have remained almost static (Figure 1) and under present condition the country is unlikely to be able to accommodate significantly more farm animals (Bonsma & Joubert, 1957).

During this period the production of red meat has increased at a rate of 4,1% per annum (Figure 2). Despite this increase, we have now reached a turnover of only 19% in our national cattle stock. With this relatively low production (Table 1) we can at present barely meet our own demands and the demand is sure to escalate within the following half a century (Figure 8). This reduction of per capita availability of agricultural and animal resources necessitates increased productive efficiency.

A high reproductive output is a basic requirement for an efficient system of animal production. Although no recent reliable statistics are available, the average calving rate of the South African beef cattle population is estimated at less than 50% and the reproductive efficiency of the predominant sheep breed at 63% (Hofmeyr & Boyazoglu, 1965). These low reproductive efficiencies are largely responsible for the low turnover of our farm animal stock (Table 1) and for this reason further discussion will be limited to research in reproductive physiology.

The Role of reproductive research in animal production

The development of artificial insemination (AI) in farm animals is considred to be one of the major advances in reproductive research. This technique which was developed in Russia (Ivanov 1897–1907) for use in livestock was originally used only in mares. However, the October Communist Revolution in 1917 and the ensuing famine necessitated the large scale application of AI in Russia in order to increase their livestock numbers. It was only during the early 1940's that this technique with its many advantages was implemented in the British Isles, again when conditions following World War II made increased animal production imperative (Rowsch, 1971). Devising suitable progeny and performance testing programs followed (Robertson & Rendell, 1954) and within nine years milk production per cow in England increased by 15% and in Japan over a period of 13 years by 74% (Van Rensburg, 1966). The tremendous advantages of this technique were soon realised and with the advent of frozen semen the application of AI increased at an almost frightening rate in most countries of the world.

In South Africa, AI cooperatives serving the largest part of the cattle farming areas were established during the years 1949–1950. At present frozen semen can be distributed to all areas of the country and yet only 5–7% of the total cow and heifer population is inseminated annually (Table 2). This also results in poor milk recording and evaluation of bulls (Tables 3 & 4).

From the statistics of the low reproductive efficiencies of national livestock and the low market penetration of AI in South Africa it is obvious that at present there is no great demand for any real increased production. The reason for this can be either ignorance or absolute satisfaction of the producer. However, since projections into the future show that a tremendous escalating demand is inevitable, a realistic approach by the animal scientist would be to develop, test and have available various techniques when the industry demands them.

Advances in controlled breeding

In South Africa ample scope exists for increasing reproductive efficiency by modifications of the traditional methods of breeding, feeding and management (Vosloo 1974, Van Marle, 1974). However, further improvement in production can also result from the appropriate application of controlled breeding techniques.

So for instance, the advantages of AI in sheep and beef cattle are not exploited, this probably being partly due to the limitations set by the extensive nature of these types of farming in South Africa (Table 5). This could be radically altered by efficient acceptable artifical control of oestrus and ovulation. In France research and development has already done this for sheep and goats by merely utilising the available research knowledge. These techniques which involve the administration of progesterone or more potent progestogens by injection, per os, subcutaneous implants, intravaginal sponges, intravaginal silastic rubber coils and topical application have been extensively studied in cattle. With the discovery of the prostaglandins (PG) the luteolytic effect of $PGH_{2\alpha}$ was employed as method of controlling the corpus luteum. Pharmacological advances brought more potent prostaglandins and by utilising these and the rapidly increasing research knowledge it soon became possible to control oestrus and ovulation in the cyclic animal efficiently without impairing fertility.

Another limitation to the practice of A.I. in sheep and cattle under extensive conditions is the problem of oestrus detection. For this and several other reasons it would be an advantage to inseminate animals at a predetermined time without heat detection. In sheep, AI at a fixed time is now possible and this technique is employed with great success in France and Ireland (Gordon, 1976).

In cattle, similar reasuring evidence is required and efforts are proceeding towards simple techniques which can be used for widespread field testing (Gordon, 1976).

Induction of oestrus and ovulation

In South Africa the annual calving percentage of less than 50 implies that cows calf in alternative rather than successive years. In the ideal situation of a calf per cow per year, a cow is allowed an average period of 86 days within which uterine involution should be completed and ovulation and oestrus should occur. Although the occurrence of these events (especially the resumption of cyclic ovarian activity) are greatly influenced by nutrition, advances into the pharmacological induction of early post partum oestrus have been studied and proved fruitful. Several workers have shown that progestogen treatment for 14 to 20 days from about 20 days post partum can reduce the interval between parturition and conception (Table 6). Recent advances in the field of synthetic gonadotrophin releasing hormones (gnRH) also have provided us with potent and efficient Synthetic GnRh.

Administration of this releasing factor has proved to efficiently initiate fertile ovarian and oestrus activity during anoestrus in cows (Table 7) (Humke & Zuber, 1977).

In anoestrus sheep and goats, induction of oestrus and ovulation is aimed at increasing the frequency of lambing. In contrast to many countries, particularly those in the Northern Hemisphere, there is no well-defined lambing season in South Africa. However, although most breeds in South Africa show some seasonal variation in reproductive efficiency, some breeds have a less restricted breeding season which makes it possible to lamb three times in two years without the use of hormone treatment (Hunter, 1968). If the need should arise for even further increases involving total intensification at the rate of a lamb per ewe at six month intervals it will be necessary to resort to hormonal treatments and early weaning. At present such a system is however considered impractical (Vosloo, 1974).

Breeding at a younger age

The breeding of farm animals at a younger age is an obvious means of raising production. It is a well-established fact that farm animals reach puberty at a certain mass rather than at a certain age. Thus provided animals are well-grown they can be mated with success at an early age. Recently attempts have been made to induce artificially cyclic ovarian activity or puberty in young animals. However, although it has met with reasonable success in sheep, variable success in pigs and little in cattle (Gordon 1976) this field may be further exploited in future.

Multiple Births

The twinning rate in cattle is relatively low (Johansson, 1932; Hendy & Bowman, 1970, Scanlon Gordon & Sreenan, 1973, Johansson Lindhé & Pirchner, 1974) and it is accepted that there is virtually nothing that can be done in the fields of feeding and management of the cow to raise the twinning rate to a level of practical importance. In addition the heritability of the twinning trait in cattle is extremely low (Preston & Willis, 1976). However, the development of a commercially acceptable artificial twinning technique could be of considerable interest as a possible means of increasing the efficiency of production.

In cattle the use of Gonadotrophins (PMSG) to increase ovulation rate has been found to be unreliable and subject to large individual variation. However, a great deal of work is still being performed on this technique in France because it has such enormous advantages of increasing calf production tremendously with a very simple treatment (Maulion, 1974). Similarly, in sheep the problem of cost, reduced conception and unpredictable litter size (Table 7) limits the practical application of this method at present (Vosloo, 1974). Nevertheless, many highly prolific sheep breeds exist (e.g. Finnish

Landrace, Russian Romanov, S.A. Mutton Merino) so that the scope for increasing prolificacy is enormous.

The low twinning rate in cattle is described by Rowson (1971) as somewhat of a biological enigma in that a cow is supplied by nature with four teats and by man with a milk production sufficient to raise four or more offspring and yet she produces only a single calf. Sheep on the other hand have only two teats often insufficient milk to raise more than twins, and yet some breeds produce up to five offspring at a time. For this reason a great deal of effort has recently been put into research on ovum transfer as a means of increasing productivity in cattle. Although surgical methods of ovum transfers are more successfull at present, for ease, financial and ethical considerations the non-surgical method appears to be the technique of choice (Hendricks, 1977).

At present the main idea with ovum transfers is one of the rapid increase of female germ plasma of outstanding value (Table 9). However, much work has been done in using this technique as an adjunct to twinning, by transferring an additional embryo to an already mated cow (Gordon, 1976).

Further work in this field includes the harvesting of fertilised ova from abatoir material and storing these temporarily in rabbits or at low temperatures. Although tremendous future possibilities lie in the development of this technique (Table 9) it is doubtful whether it can be with propagated at present in South Africa even as a means of increasing germ plasma of outstanding value. If AI has only had an acceptance of 6% it indicates that the full scale application of less successfull more complicated techniques are not yet warranted. A further point of doubt rests in the accurate evaluation of female animals superior enough to justify her utilisation as a donor.

Sex Selection

A further finding which resulted from work on ovum transfer and embryo cultivation was of that the 12-day old sheep-embryo could be sexed by observing the Y chromosome (Polge & Rowson, 1973). However, this involves the removal of a few cells from the conceptus before transfer and examining the karyotype – a rather tedious process with somewhat limited practice implication (Towson, 1971). Rowson further states: "A more convenient method of obtaining the same result would obviously be sex determination by separation of the X and Y-bearing spermatozoa. But most attempts at this have failed and the theoretical concepts on which such efforts at separation have been made are highly suspect. To expect a difference in mass between X and Y chromosomes to be greater than the individual differences in the mass of cells themselves, is stretching the imagination to an impossible degree, nor would there be any sound evidence that the electrical charge on X-or-Y bearing spermatozoa should be different". However, recent advances in this field have proved that by means of sedimentation some degree of shift as high as 87,5% male to 12,5% female can be obtained in bull semen (Bhattacharya, Shome, Gunther & Evans, 1977). Similar results have been obtained by sephadex gel filtration by which the percentage X bearing spermatozoa have been increased form 63% to 96% (Steeno, Adimoelja & Steeno 1975; Ademoelja, Hariadi, Ametaba, Adisettya & Soeharno, 1977). Recently the popular press advocated a change in vaginal pH as a method of sex control. Observations on sheep differing in vaginal pH gave negative results (Van der Westhuysen, 1968). Similar results in the human have also been published (Broer, Weber & Kaiser, 1977).

Radioimmunoassay (RIA) and Animal Production

Apart from the wealth of knowledge in reproductive physiology which followed the advent of R.I.A., this basic knowledge found more direct application in animal production. So for instance it was soon realised that the plasma or milk progesterone concentration on day 21 to 24 following mating could be used as an accurate method of pregnancy detection in cattle (Pope & Hodgson-Jones L.S., 1975; Hoffman & Hamburger, 1973).

In addition more recent work (Holness, Ellison, Sprowson & De Carvalho, 1977) has shown that the plasma progesterone concentration in the luteal phase of the previous cycle can be used as an indicator of fertility at the following estrus.

In sheep, the use of RIA to determine gonadotrophins in lambs resulted in the development of a technique of selection of male (and female) animals for their later prolificacy on their early gonadtorphic status (Bindon & Turner, 1974; Land, 1974; Carr & Land, 1974). Although not yet sufficiently tested, this technique may supply us with a method to quantify the prolificacy of rams as a selection parameter. This technique is also currently being tested for use in cattle (Bindon, 1974).

Increasing production in South Africa

It is obvious that tremendous advances have been and still are being made both in pharmacological and physiological research. Methods have been developed to control reproduction and aid reproductive efficiency of farm animals. However, these developments are no general panacea against reproductive problems, but should be considered as an advanced form of animal production with the prerequisite of optimal reproductive efficiency of the animals in which it is to be applied. So for instance, if one takes a broad look at the South African animal production picture it is clear that, on the whole, this country is not yet ready for the general application of these modern techniques. The immediate problem lies in the low reproductive efficiency of our farm animals which is the result of poor management accompanied by inadequacies in nutrition, disease control and husbandry. Joubert (1975) stated that: "These matters can be rectified only through education and training. Once these obstacles are overcome intensification of methods will become necessay if higher production is sought." However, one cannot generalise since in some cases the application of these intensified methods is already practicable, depending on the demand for the products thereof. In South Africa, the slow increase in animal production and the incredibly low interest in techniques such as AI indicates a relatively low demand (production interest) at this stage.

However, increased demand is inevitable and more food will have to be produced from the same area of agricultural land. This together with the economic pressures is inevitably going to result in some degree of intensification. Individual suppliers are therefore going to become more and more interested in utilising the available knowledge for expanding production in the direction of so called factory farming. It inevitably follows that more research will have to be done so that the necessary methods are available when they are demanded.

In view of the time factor and limited manpower such research should be organised and coordinated to involve everyone concerned in that field whether they be from the universities, the government departments or the private sector. Closer cooperation, regular communication and efficient working groups should report on their progress at regular intervals so that the significance of further research in that particular field could be discussed or the investigation liminated. Final decisions and the outcome of research should reach the animal producer and it has been shown in this country, and overseas that a great deal of valuable information can be gathered by working in close cooperation with farmers.

Finally, there is a need for greater awareness in government circles, in industry and amongst the public that research and especially cooperation can play an important role in the development of useful knowledge. "Biological discoveries will, from time to time, offer quite new potentialities to production, but will require much effort for their realisation" (McDonald, 1971).

Fig. 1 Changes in the number of cattle, sheep and goats and pigs in South Africa from 1950 to 1977 (Abstr. of Agric. Stats. 1978)

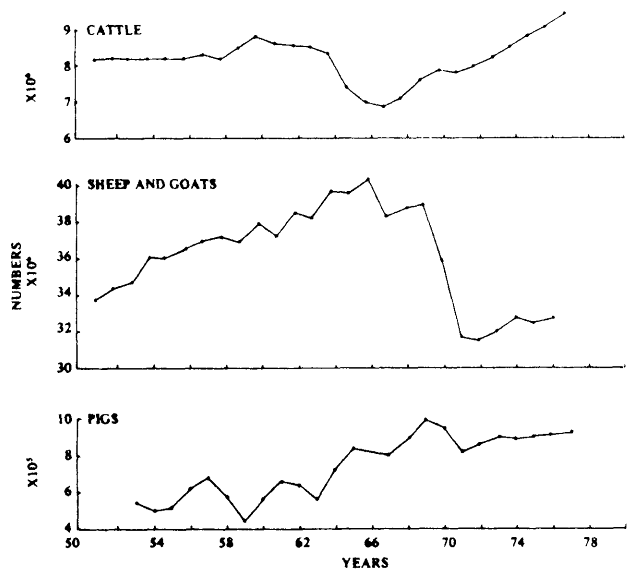

Fig. 2. Changes in the production of meat from cattle sheep and goats and pigs in South Africa from 1950–1977 (Abstr. Agric. Stats. 1978)

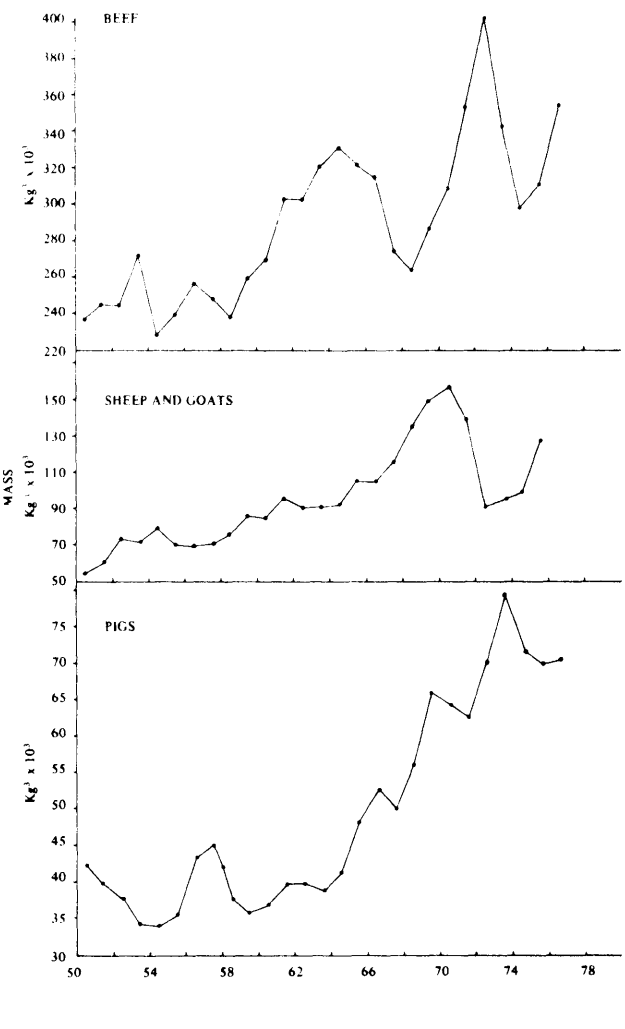

Fig. 3 Anticipated growth of the total population of South Africa up to the year 2020 (Dept. Agric. Tech. Services Annual Report 1972–1973).

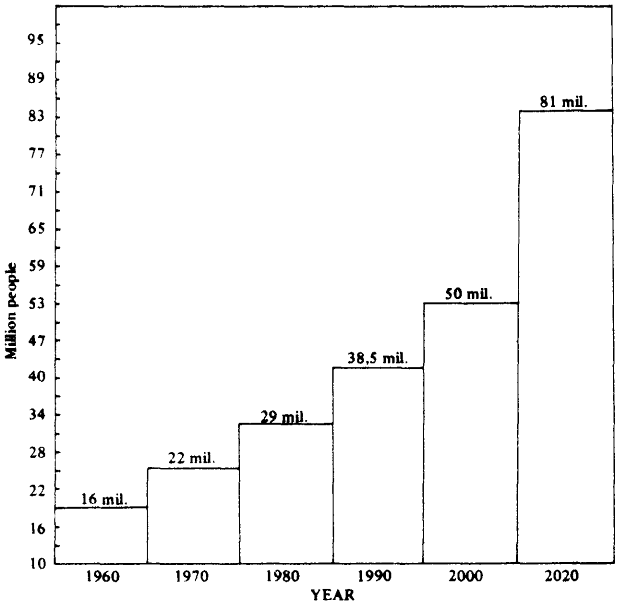

Table 1

The turnover of national cattle stocks

LAND	TURNOVER
FRANCE	40%
NEW ZEALAND	36%
U.S.A.	35%
AUSTRALIA	23%
SOUTH AFRICA (Whites)	19%
BLACK HOMELANDS	4%

Table 2

Percentage of all dairy cows and heifers artificially inseminated in different countries

Country	Year	%
Denmark[1]	1964	100
Japan[2]	1960	97
Czechoslovakia[1]	1962	85
Poland[3]	1976	82
Holland[1]	1964	73
England & Wales[1]	1962	66
France[1]	1964	65
U.S.A.[3]	1976	45
New Zealand[1]	1965	31
Scotland[1]	1962	19
South Africa[4]	1978	8

From [1]Lerner & Donald (1966) [2]Van Rensburg (1966) [3]Gordon (1976) and [4]Dicks (personal communication)

Table 3

Artifical insemination and milk recording in the active breeding population of dairy cattle in Sweden and South Africa (Osterhoff, 1974)

Percentage of population	Sweden %	South Africa %
No AI and No recording	20	89
AI, no milk recording	35	6
Milk recording, No AI	5	3
AI and milk recording	40	2
	100	100

Table 4

Average age of Dairy Bulls at first evaluation (Osterhoff, 1974)

South Africa	9,3 years
Sweden	5,2 years

Table 5

Artifical insemination of total Dairy and Beef cattle populations in South Africa and U.S.A.

	Dairy Cattle	Beef Cattle
South Africa[1]	8%	2%
U.S.A.[2]	45%	2%

([1]Dicks, Personal Communication; [2]I. Gordon, 1976)

Table 6

Effect of post-partum interval in dairy cows on synchronized oestrous response following the 12-day intravaginal progesterone treatment (Roche, 1976)

	Post Partum Interval (days)	Number of cows	Observed in oestrus (%)
CONTROL COWS	10–30	35	17
	31–45	29	52
	>45	14	100
TREATED COWS			
No prior oestrus	10–30	22	45
	>30	13	92
Prior oestrus	>30	34	97

Table 7

Treatment of anoestrus cattle with GnRh (Humke & Zuber, 1977)

TREATMENT	% Cows in oestrus after treatment 24 Days	36 Days	% Pregnant after 1 insemination
Vitamin Injection (control)	16%	40%	11%
GnrH (nona peptide)	70%	84%	51%

Table 8

The effect of progestagen – PMS treatment on lamb production in South African Mutton Merino ewes (Botha, 1976)

		Distribution of Litter size (%)				
MONTH	TREATMENT	1	2	3	4	5
August	No	42	58			
	300 i.u. PMS	48	45	7		
	600 i.u. PMS	22	30	32	6	10
March	No	50	50			
	300 i.u. PMS	40	60			
	600 i.u. PMS	22	63	12	6	0

Table 9

Contributions of embryo transfer to animal production (Church and Shea, 1977)

CONTRIBUTION	ROLE IN ANIMAL PRODUCTION
Rapid gene pool expansion	Expand gene pools of rare breeds or in controlled geographical regions.
Increase selection intensity in females	Approximately double selection intensity among offspring of selected dams in beef cattle.
Increase twinning rate	Increase number of calves produced per gestation.
Facilitate seed stock transport	To aid transport of diploid genome of frozen or cultured embryos with reduced disease hazard from country to country.
Utilized prepubertal oocytes and in vitro fertilization	Reduce generation time and utilize genetic potential of more oocytes present in bovine ovary.
Gene – environment interaction studies	Facilitate research into maternal-fetal interactions with reference to reproductive rate, pharmacological and disease states.

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