THE PRESENT STATUS OF APPLIED REPRODUCTIVE PHYSIOLOGY IN ANIMAL PRODUCTION

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SUMMARY

The reasons for the relatively limited penetration into animal production of innovations in applied animal reproductive physiology are discussed. Application is as dependent upon economic and human factors as upon the technical value of the innovation. The need for integration of complementary techniques to provide whole working models is stressed and examples presented.

Despite the immense effort expended on research in animal reproductive physiology, relatively little appears to have been achieved in terms of practical application. Notwithstanding high hopes and optimistic predictions about developments such as the use of egg transfer for inducing twinning in cattle, or transport of flocks and herds across the world in test tubes, relatively few techniques have found their way into everyday animal production.

The major advance has been the widespread application of artificial insemination of dairy cattle, commonly associated with the use of frozen semen. The relative ease of freezing bull semen, the intensive nature of dairy cattle husbandry involving twice daily handling of the breeding herd, and the high value of the product have made this a natural development. In a number of countries the artificial breeding scheme forms the backbone of national herd improvement programmes.

Having said that, there is little to add concerning techniques that have emerged from animal physiological studies and are universally accepted in practice. It is true that artificial insemination of poultry is widely used in flock improvement programmes, and artificial lighting is used to alter the normal annual pattern of production; that the Russians have used artificial insemination of sheep on a large scale in grading-up programmes; and that in some regions fairly large numbers of swine are artificially bred. But these operations are very minor in relation to the size of the respective industries. Furthermore, the techniques used have changed very little over the decades. Behavioural studies have shown the importance of a full oestrous response in the sow to obtain an acceptable level of fertility, but although the factors contributing to this

response are now known, relatively few sows are inseminated. Of those countries for which data are available, only in the Soviet Union are more than 100,000 sows inseminated annually. The figure lies between 50,000 and 100,000 for each of Holland, United Kingdom, France, Japan, and the socialist states of Eastern Europe.

This represents a lamentably poor penetration of commercial animal production. Even such a longstanding and well-proven technique as artificial breeding of dairy cattle has made only limited penetration in some so-called developed countries, and has not made its potential impact in cattle breeding plans. The use of frozen ram semen is extremely limited, despite reports of its success. Thus, Salamon and Visser (1974) have reported 53% lambing rates in Australia following the use of semen frozen and stored for five years. Satisfactory results have also been reported from France (Colas *et al.*, 1971).

The commercial utilization of the "Cronolone" impregnated intravaginal sponge, with or without PMSG, is virtually restricted to France and Ireland, although the technique is now penetrating other countries, albeit on a limited scale. The use of corticosteroids for the induction of accurately-timed and synchronized parturition is limited. This is understandable, perhaps, in view of the more recent development of this technique. It is a technique that could be discredited and its use curtailed through misuse or misunderstanding.

In another category is the methallibure-PMSG technique for the synchronization of oestrus in swine, particularly in gilts. The chance discovery of the effect of methallibure on the hypothalamic-pituitary axis led to the development of an excellent technique which has subsequently been forbidden because of the possibility of a teratogenic effect. This has delayed the implementation of large-scale swine insemination programmes in the industrialized countries where labour is at a premium.

More recently the prostaglandins have come to the fore. There are high hopes in some quarters that these compounds will revolutionize animal breeding and provide effective means of synchronizing oestrus in cattle and sheep. Certainly, there are reports of a high degree of synchronization and of good fertility following insemination of cattle, but equally good results can be obtained with other and older methods such as intravaginal progestagens (Smith, 1973). These have been available for a decade but are not widely used.

Why has there been such limited adoption of techniques such as artificial insemination of sheep using either fresh or frozen semen, advancement of the breeding season using intra-

vaginal progestagen plus gonadotrophin, synchronization of oestrus in sheep with intravaginal progestagen or silastic implants and the associated use of corticosteroids for synchronized parturition? Is it because the techniques themselves are insufficiently reliable or are other factors—economic and human—involved?

All are involved. In considering, first the technological factors, it must be recognized that any manipulation of natural phenomena involves an element of risk. Large field-scale application of techniques which give satisfactory results in the laboratory commonly lead to disappointment. Furthermore, the many environmental factors which interact on biological phenomena such as reproduction are often not taken into account. The organism has a remarkable capacity to adjust its reproductive performance to its environment, in particular, its nutritional environment. Much of the low fertility observed in sheep following the use of progestagen sponges in Australia can be attributed to the fact that their introduction and widespread testing was carried out during severe drought years. Seasonal effects on fertility, which in Merino ewes tends to be masked under conditions of high nutrition and prolonged joining with rams, are accentuated and thrown into sharp relief when one attempts to use controlled breeding techniques (Robinson, 1971). Although the semen of the ram, the buck, and, more recently, the boar, has been successfully frozen there are still problems with thawing and insemination procedures which can lead to failure even in experienced hands. At best, fertility is somewhat below normal and, when one attempts to associate controlled breeding of the ewe or goat-doe with the use of frozen semen for insemination, very poor results may ensue. This is not invariable and some of the French results have been quite good, particularly when serum gonadotrophin has been used in association with intravaginal progestagen (Colas *et al.*, 1971). However, the unreliability is such that frozen ram or buck semen is not now used in the commercial application of controlled sheep and goat breeding in that country. In the pig, several relatively small-scale experiments have yielded moderate to satisfactory fertility following normal insemination with frozen-thawed semen, but the repeatability of these results remains to be confirmed. The problem of lowered fertility can be overcome by surgical insemination which, despite its obvious disadvantages, offers reliable fertility and is applicable to special circumstances such as international transport of genetic material and long-term storage of semen of particularly valuable animals. Clearly, this application will be limited.

Egg transfer in cattle, involving the use of prostaglandins for the associated synchronization of oestrus, is in a similar category. Egg transfer is feasible—at a price—but could not be considered using present techniques were it not for the inflated values of the exotic breeds and their crosses. Techniques will have to be greatly simplified and reduced in cost if they are to be widely used in commercial beef production, even in Europe where animal production is highly intensive and beef prices several-fold higher than here.

The economic and human factors involved in the acceptance and widespread use of innovations have been largely underestimated. Controlled sheep breeding in Australia and New Zealand has failed to make an impact for these reasons as much as for reasons of technological defect. It is true that there was a failure to recognize the limitations of the technique in relation to nutritional status of the ewe, season of the year, and limitations in production of spermatozoa by the ram. But these limitations have not prevented the spread of the technique in Europe. There, the economics of the lamb industry are such as to provide a stimulus to overcoming the technological problems (Tables 1 and 2).

But this is only part of the story. Despite the comparable economic stimulus in the United Kingdom, on the one hand,

TABLE 1: VALUES OF LAMBS—FRANCE, 1972-3

Season	*Age (days)*	*Sex*	*Single or Twin*	*L'weight (kg)*	*Carcass wt (kg)*	*Value ($A)*
Out of season	100	M	S	38	19	48
	100	F	S	32	16	40
	100	M	T	32	16	40
In season	100	M	S	38	19	38
	100	F	S	32	16	32
	100	M	T	32	16	32

TABLE 2: VALUE OF ANNUAL PRODUCTION PER EWE—FRANCE, 1972-3

No. lambs	*Sex of lambs*	*Season of Lambing*	*No. Lambings/yr*	*Gross Value of Production ($A)*
1	M	In	1	38
1	M	Out	1	48
2	M	In	1	64
2	M	Out	1	80
2	M	In / Out	2	85
3	M	In / Out	2	112

TABLE 3: RESULTS OF EARLY BREEDING TRIALS IN EIRE
(Gordon, 1973)

	1965-7		1968-9	
	1900 ewes in 60 groups		*759 ewes in 56 groups*	
	1st heat	*2nd heat*[1]	*1st heat*	*2nd heat*[1]
Percentage bred	77%	78%	98%	70%
Conception rate	40%	70%	62%	71%
Lambs/conception	1.5	1.4	1.7	1.4
Lambs born per 100 ewes treated	47	53	100	25
	100		125	

[1] Ewes not pregnant after first heats which returned one cycle later.

and France and Eire on the other, little has been done in the United Kingdom and a great deal in France and Eire due, as far as can be seen, entirely to the human factor. In Eire, Professor Ian Gordon saw the potential of "Cronolone" sponge-PMSG treatment for advancing the production of prime lamb and virtually single handed pushed the technique out on to some 500 farms. The type of results obtained is shown in Table 3. Gordon has been so successful that this husbandry technique is now an accepted practice supervised and administered by the Department of Agriculture. In 1972 some 20 000 extra lambs were produced for the Easter market, most of them for export (Gordon, 1973).

TABLE 4: SUMMARY OF PRODUCTION DATA IN LARGE SCALE INTENSIVE LAMB PRODUCTION—MARNE REGION, FRANCE

Total ewes	2200	
Conception rates	Agnelles [ewe lambs] 75%	
	Ewes dry—breeding season	75%
	—non-breeding season	60%
	Ewes wet—breeding season	65%
	—non-breeding season	50%
Lambs born/100 ewes/yr	All ages, 250-280	
Losses of lambs	20%	
Lambs sold/100 ewes/yr (mean of 3 yr)	210	
Age at sale	120-180 days	
Liveweight at sale	40 kg	
Price paid/lamb ($A)	$45-50	
Gross production/ewe/yr ($A)	$100	
Labour force	4 men	
Gross return/annum	$220,000	

TABLE 5: SCHEDULE OF OPERATIONS USED IN THE NOUZILLY INTENSIVE LAMB PRODUCTION SCHEME

Operation	*Day of Week*
Insertion of sponges	Wed. (14-day insertion) Fri. (12-day insertion)
Removal of sponges and injection of PMS	Wed. (a.m.)
Artificial insemination	Fri. (a.m. and p.m.)
Pregnancy diagnosis—day 18	Tues.
Induction of lambing—injection of dexamethazone	Mon. (day 143 of gestation)
Lambing	Wed., Thurs., Fri.
Artificial rearing of surplus lambs	Thurs., Fri., Sat. (a.m.)

A much greater impact on the lamb industry has been achieved in France. The programme commenced in 1966 and in 1973 some 250 000 to 300 000 ewes were artificially inseminated following controlled breeding. Highly-intensive commercial production systems have been devised and data for the largest of these are presented in Table 4.

At the Physiology of Reproduction Station of the National Institute of Agricultural Research (INRA) at Nouzilly, a highly-sophisticated and intensive production unit is in operation. The flock is divided into seven groups and every 49 days —on a Wednesday—a cycle of operations commences on one-seventh of the flock (Table 5). Ewes diagnosed non-pregnant on day 18 are put into the next "wave" commencing 15 days later and are re-treated and inseminated.

Intensive controlled lamb production is now part of the national agricultural scene in France and is being spread to Spain and Italy.

Despite some limited interest in the United Kingdom and an excellent experimental unit at the Rowett Research Institute in Scotland (Orskov and Robinson, 1972) the technique is not spreading commercially.

In Eire, the scheme has developed because of the enthusiasm and drive of one man. In France it has developed because there was an organization available to take and develop new techniques and to meld them together into working models sufficiently simple and reliable to be applied commercially. The French scheme is sophisticated and, by Australian and New Zealand standards, expensive, but the returns are high. The National Institute of Agricultural Research is a formidable organization whose personnel range from research scientists through various echelons to field workers whose task it is to see the results of research and development

applied in practice. Further, there is excellent rapport with the appropriate branches of the pharmaceutical industry.

There is much to be learned from this. On the one hand, it is ironical that the large numbers of animals at relatively low cost that make it possible in Australia and New Zealand to develop new techniques applicable to sheep and cattle production, mitigate against their economic exploitation. On the other hand, there is a tendency not to follow through. Sometimes there are good reasons for this; other times there are not. When frozen boar semen of uniformly high fertilizing capacity becomes available, as it will in a couple of years, who will ensure that it is used to best advantage? Who will guard against its failure in the field as a result of biological factors such as an inadequate oestrous response in sows, or human factors such as inadequate training of inseminators? Who will ensure that the use of such semen is associated with effective swine improvement programmes and that herd management and nutrition are optimum to obtain maximum effective use of the new technology? When there is a simple, reliable method for the synchronization of oestrus in beef cattle, who will provide the service necessary to keep costs low and reliability high? Who will attend to the highly important details necessary to make any sophisticated system of husbandry effective? Who will introduce the early pregnancy diagnosis which will make feasible effective controlled parturition? Who will set up, improve upon and supervise whole working models? Well-integrated organizations, such as INRA in France, which cut across our traditional institutional barriers, are essential. Some of the better Land Grant Colleges in the United States, where the extension services are within the college, could handle the situation but there is no suitable structure in Australia. It may be easier to develop and implement whole production systems in New Zealand with its much more tightly knit governmental, research, and industry structure.

CONCLUSIONS

(1) There are reliable physiological techniques applicable to animal production which, either for economic reasons or for failure to appreciate their potential role in husbandry systems, are lying idle.

(2) It is essential to look at any innovation in relation to whole production systems. Synchronized breeding, early pregnancy diagnosis at day 18 in the sheep or 22 in the cow, and induced synchronized parturition are three techniques which are naturally complementary and should be regarded as such.

(3) No innovation is a panacea and each brings its own problems. Pressure on an animal, whether it be by hormone treatment for controlling the time of ovulation and oestrus or for increasing the number of ova shed or by anaesthetic for egg transfer, will almost certainly interact with the nutritional, seasonal and photoperiodic environment of the animal so that any potential weakness in the reproductive system will be aggravated.

(4) The development of new techniques, which work well in the hands of the skilled operator, is the relatively easy part of the whole operation. Some have been developed but are not applied, despite economic viability. Vision and drive on the part of individuals, and an organizational structure covering advanced research and developmental technology through to practical field testing, application and servicing, are essential.

(5) The application of new physiological techniques in animal production automatically demands a higher degree of intensification and hence of management skills. This in turn demands an increased level of technical and scientific skills in advisory and back-up services.

(6) Any innovation involving the use of new hormones or drugs which have not been given a clearance by the Government of the country concerned, or by those of countries to which one exports, is in danger. It should be ensured that the potential of techniques involving cleared compounds are examined fully before being jettisoned in favour of more "promising" techniques involving uncleared compounds. As a case in point, it should not be forgotten that, despite the attractions of the prostaglandins, the progestagens are cleared for safety and are highly effective in the control of ovulation and oestrus. The sad example of methallibure is a constant reminder.

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