Photoperiodic treatments to control seasonal sperm production in sheep and goats

Philippe Chemineau

INRAE France

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Introduction

1. Seasonality of male activity

2. Semen in Spring and Summer

3. Semen all the year round

Conclusion

Seasonality :

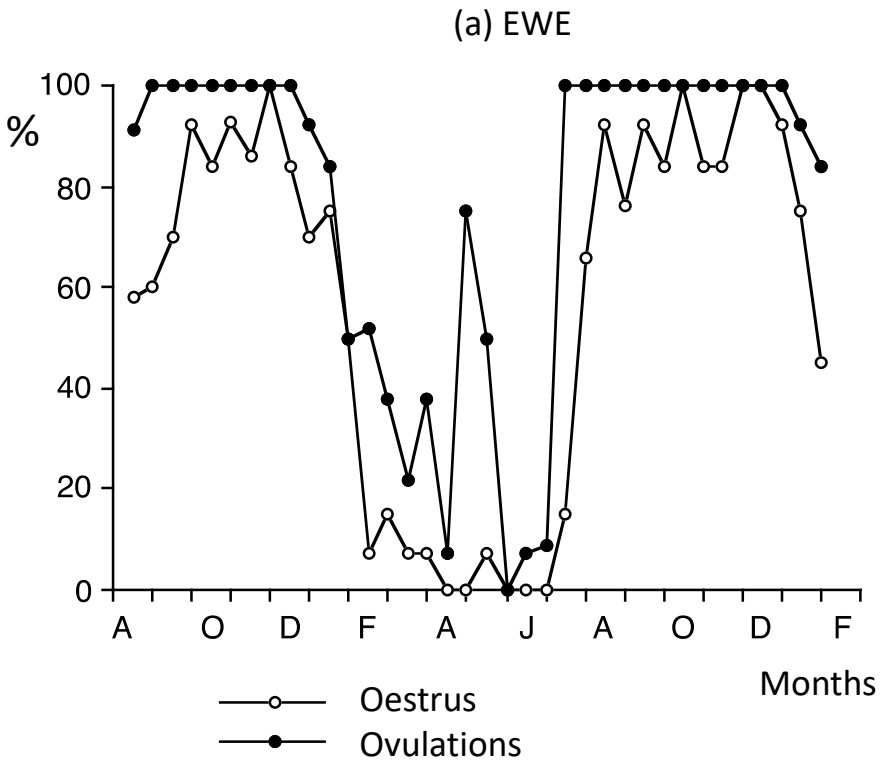
- Common trait inherited from the wild ancestors

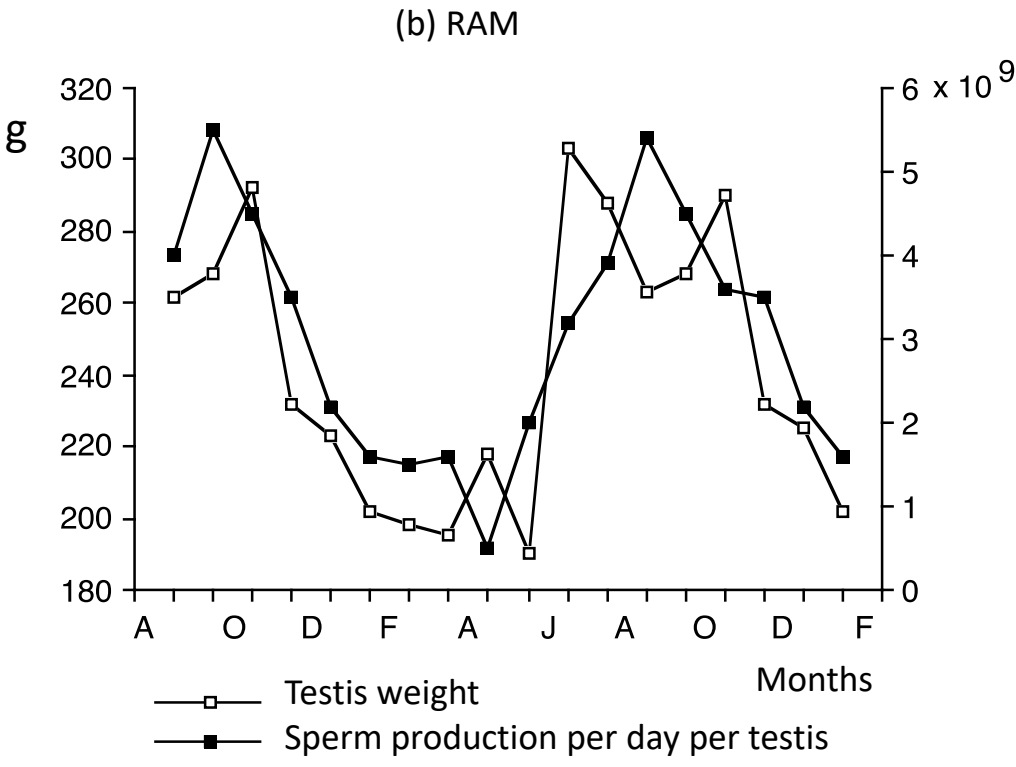
- Mainly controlled by photoperiodic changes

- Central phenomenon involving inhibition of GnRH neuron activity during sexual rest

- Major drawback for AI centers while farmer's demand is for out-of-season breeding

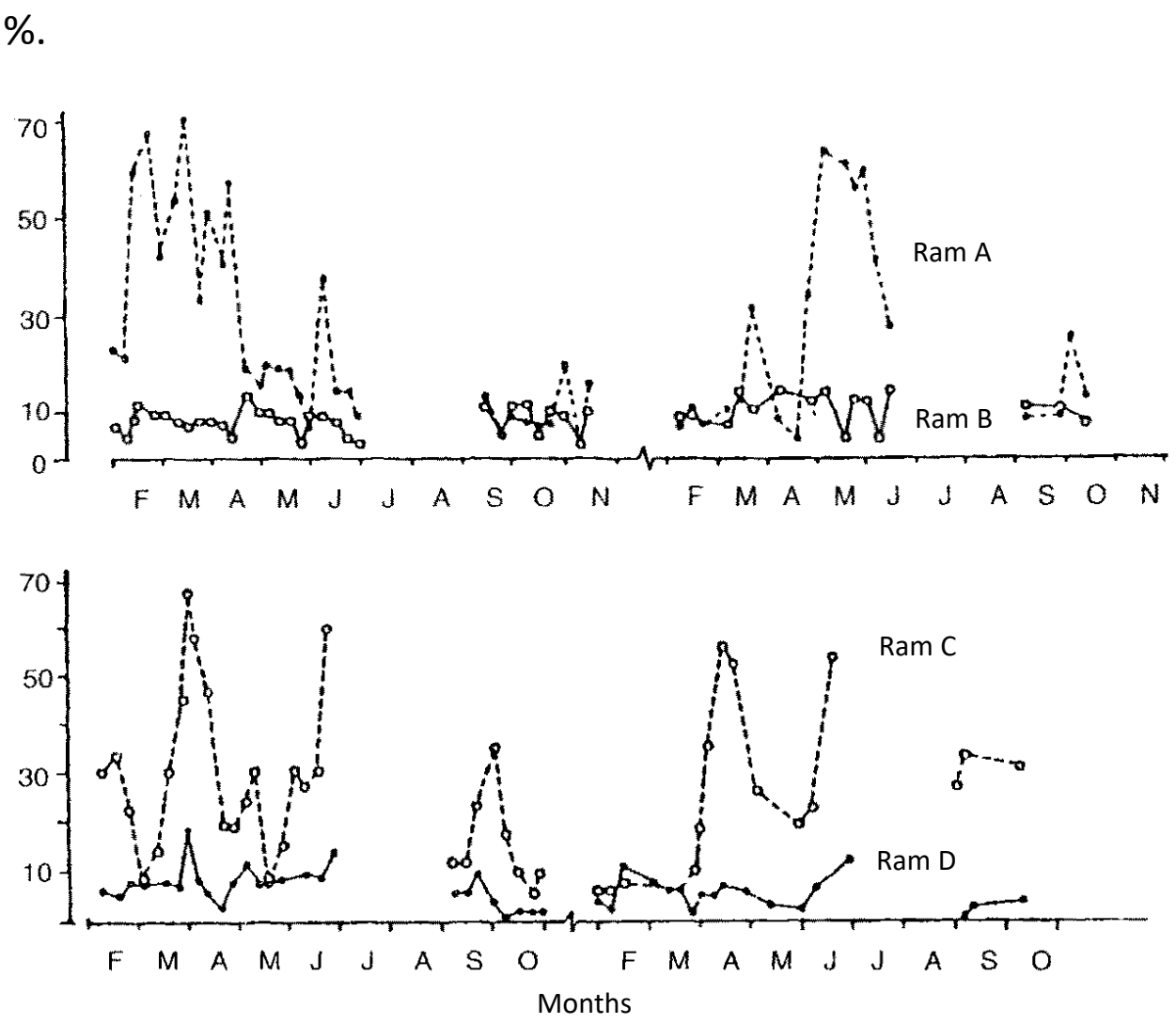
1. Seasonality of male activity



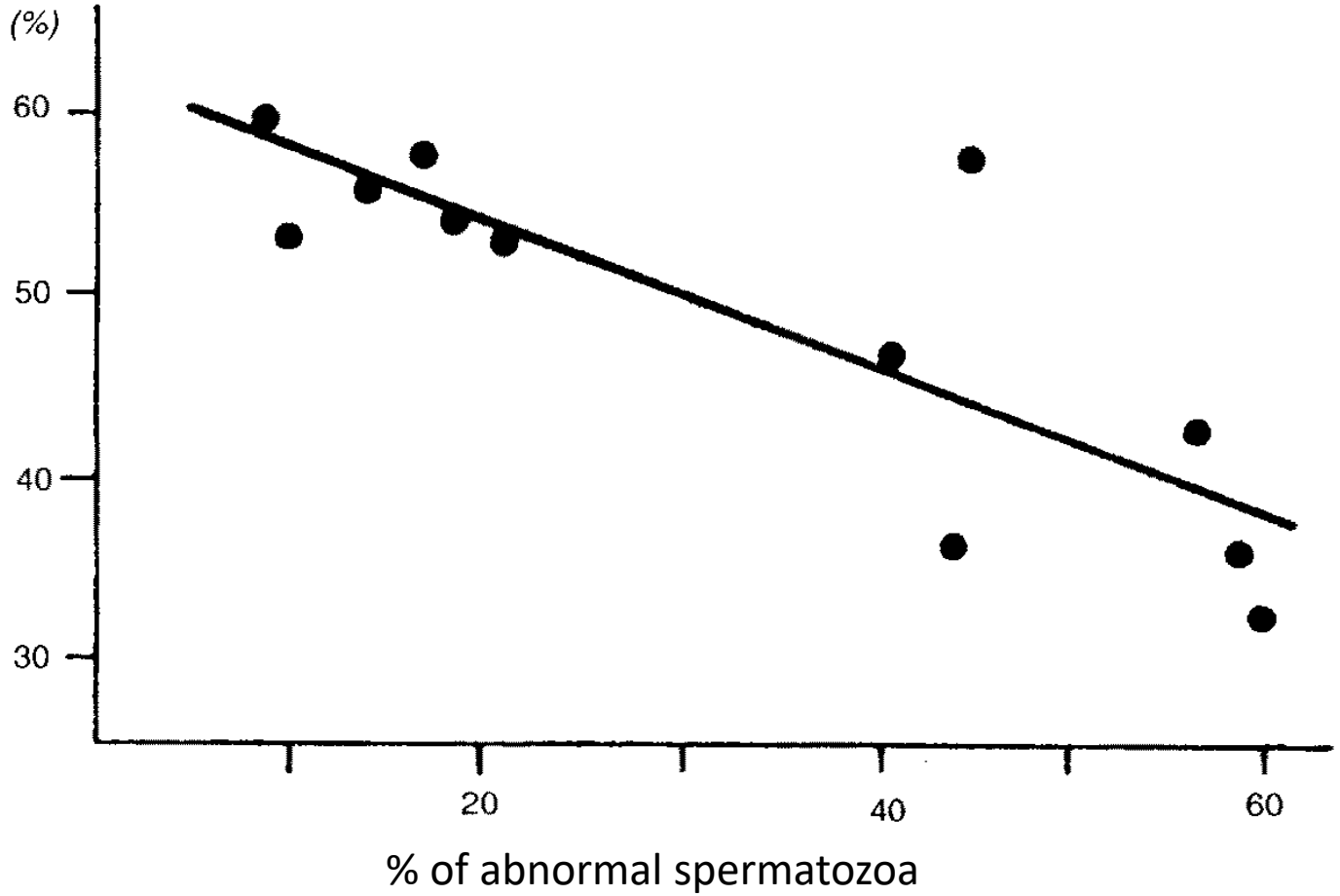


Seasonal variations (a) of the frequency of ovulations and oestrous behavior in Ile-de-France ewes (Thimonier & Mauléon 1969), (b) of testis weight (Pelletier 1971) and sperm production per testis (Dacheux et al. 1981) in Ile-de-France rams.

Long-term variations in the % of abnormal spermatozoa in Ile-de-France ram semen (Colas et al. 1986)

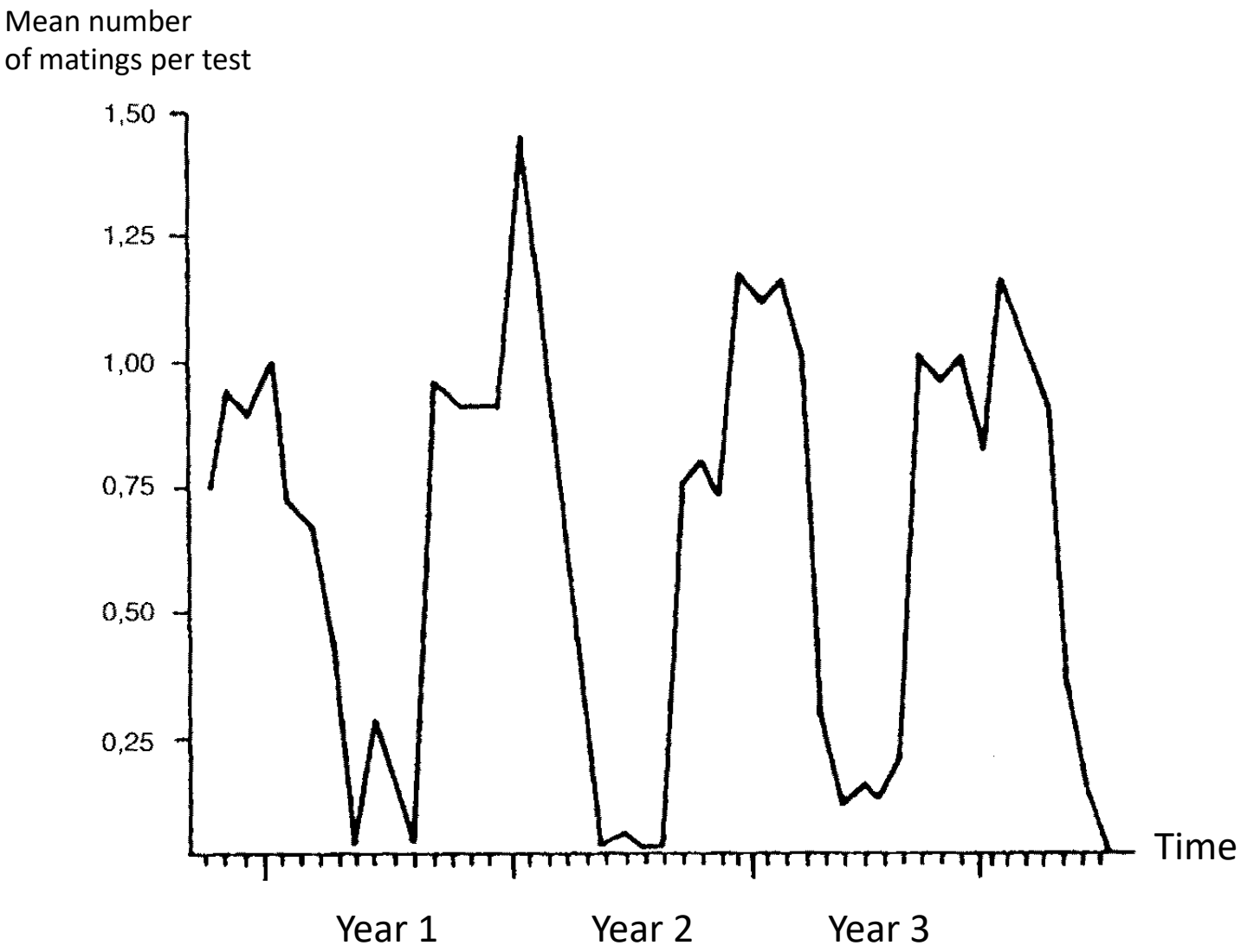


Relationship between the % of abnormal spermatozoa in ram semen and fertility of ewes artificially inseminated with liquid semen



Colas 1981

Seasonal variations in the number of matings during 10 min. tests in male Alpine goats

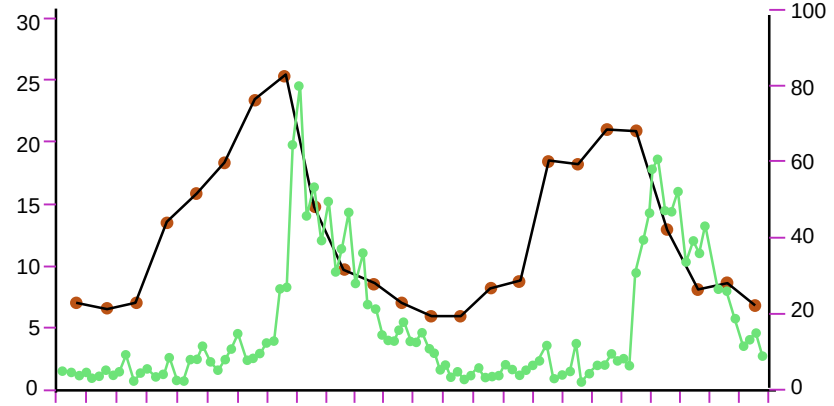


Rouger, 1974

Seasonal variations in plasma testosterone, latency to ejaculate in the artificial vagina and in sperm mobility in male Alpine goats

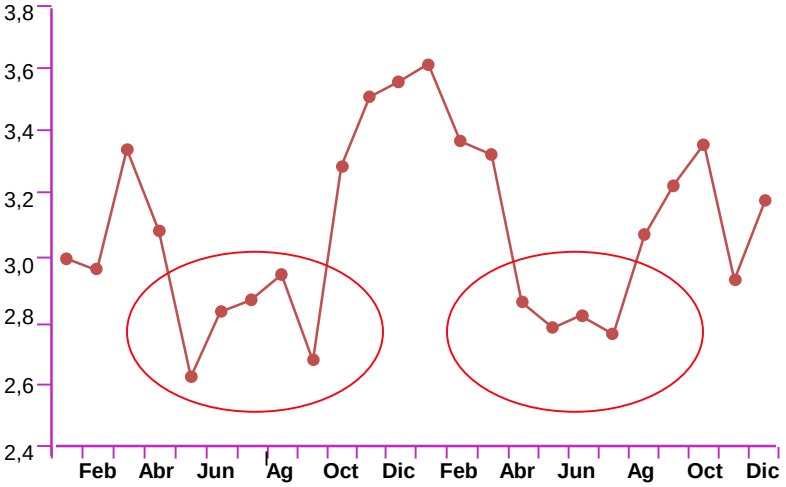
Plasma Testosterone (ng/ml)

Latency (seconds)



Sperm mobility (0 to 5)

Annual decrease in sperm mobility



Alpine bucks (1-3 years old)
(Delgadillo et al. 1991)

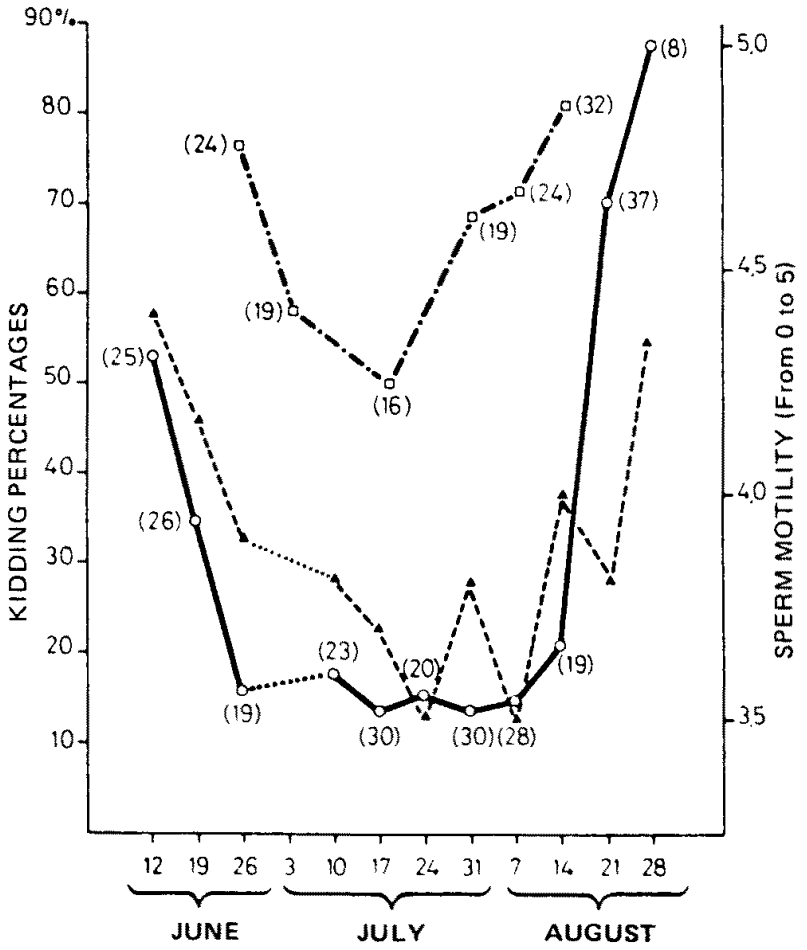
SEASONAL VARIATIONS IN SPERM MOTILITY AND FERTILIZING ABILITY

—●— : FERTILIZING ABILITY OF LIQUID SPERM (+ 4° C)

▲----▲ : MOTILITY OF LIQUID SPERM (+ 4° C)

○-·-·-○ : FERTILIZING CAPACITY OF FROZEN-THAWED SPERM COLLECTED IN THE PREVIOUS BREEDING SEASON

( ) : Numbers of inseminated females



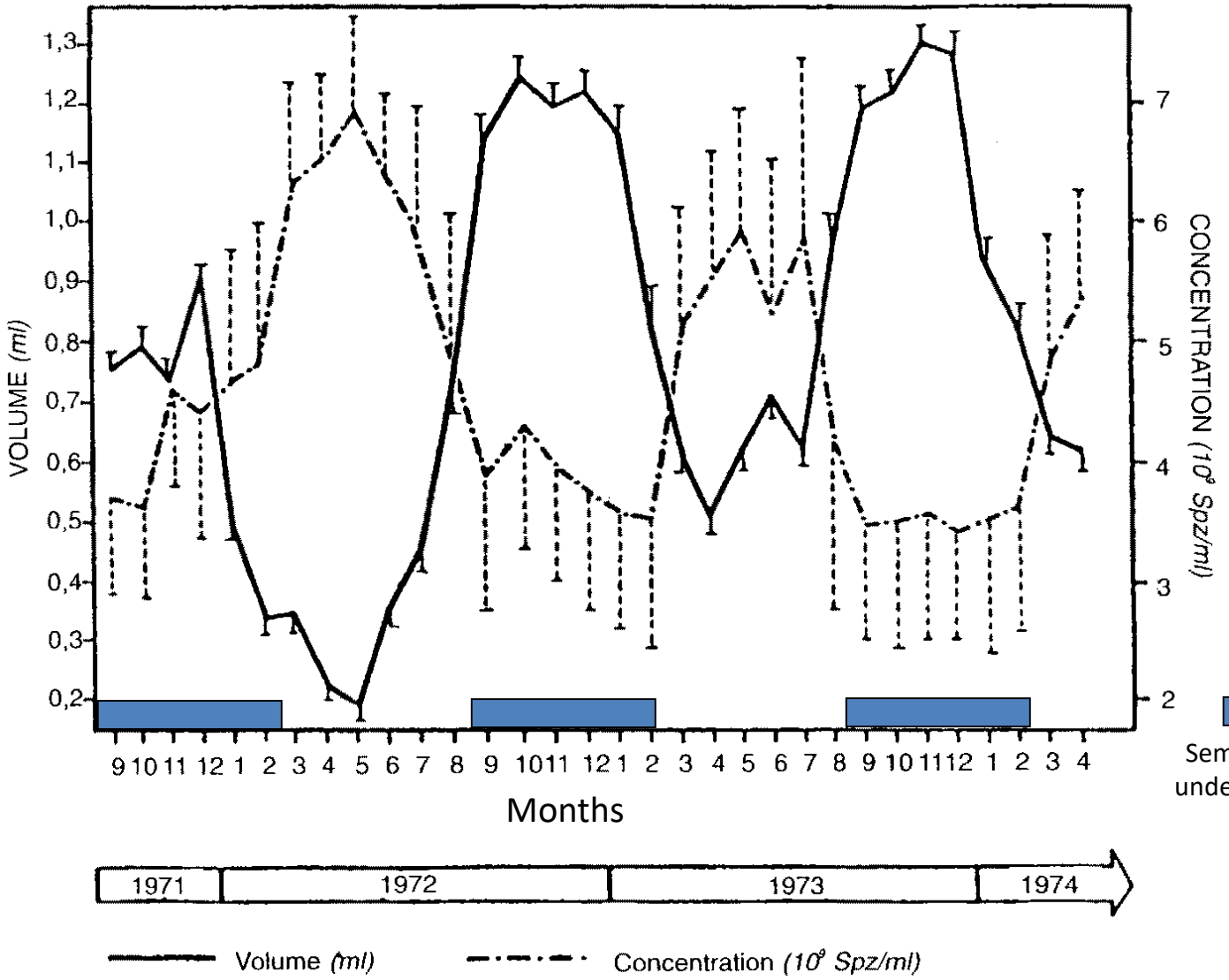
J. M. Corteel (1977)

These decreases in fertilizing ability and in sexual behaviour impose

(a) semen collection only during the breeding season

(b) deep-freezing of semen

Seasonal variations in the volume and sperm concentration of the ejaculate in Alpine bucks

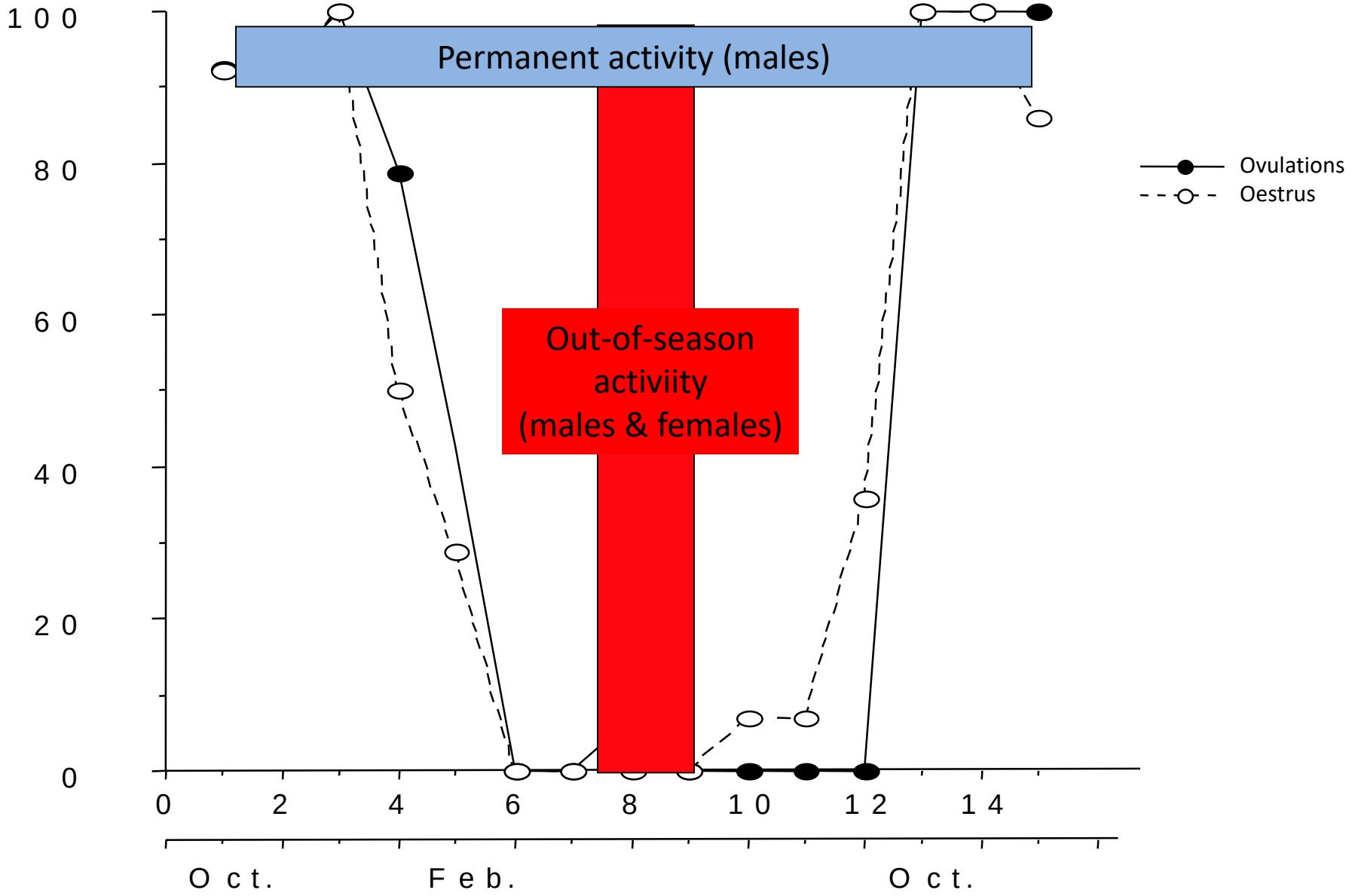


=>
These variations impose semen washing before deep-freezing (deleterious effect of seminal plasma)

Semen collection period under natural photoperiod

Corteel, 1977

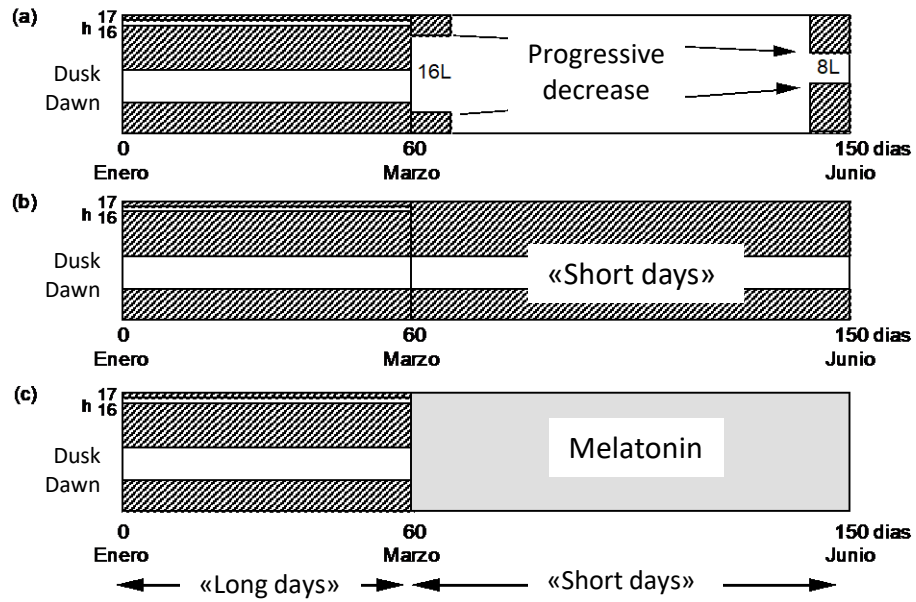
Demands from professionals relatively to the control of seasonality



2. Semen in Spring and Summer

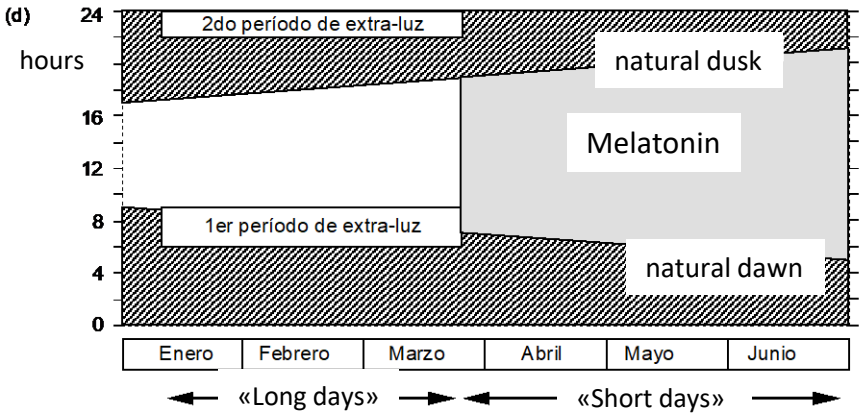
Various photoperiodic schemes have been tested in light-proof and in open barns :

Light proof barns



=> All of them are efficient

Open barns



Long Days Melatonin

Testis diameter (mm)

60
50
40

L+M

Control rams

F M A M J J A S

Sexula behaviorl (mounts per test)

4
3
2
1

L+M

Control rams

F M A M J J A S

Ejaculate volume (ml)

1,4
1,2
1,0
0,8
0,6
0,4

L+M

Control rams

F M A M J J A S

Sperm concentration x 10 9

6
5
4
3

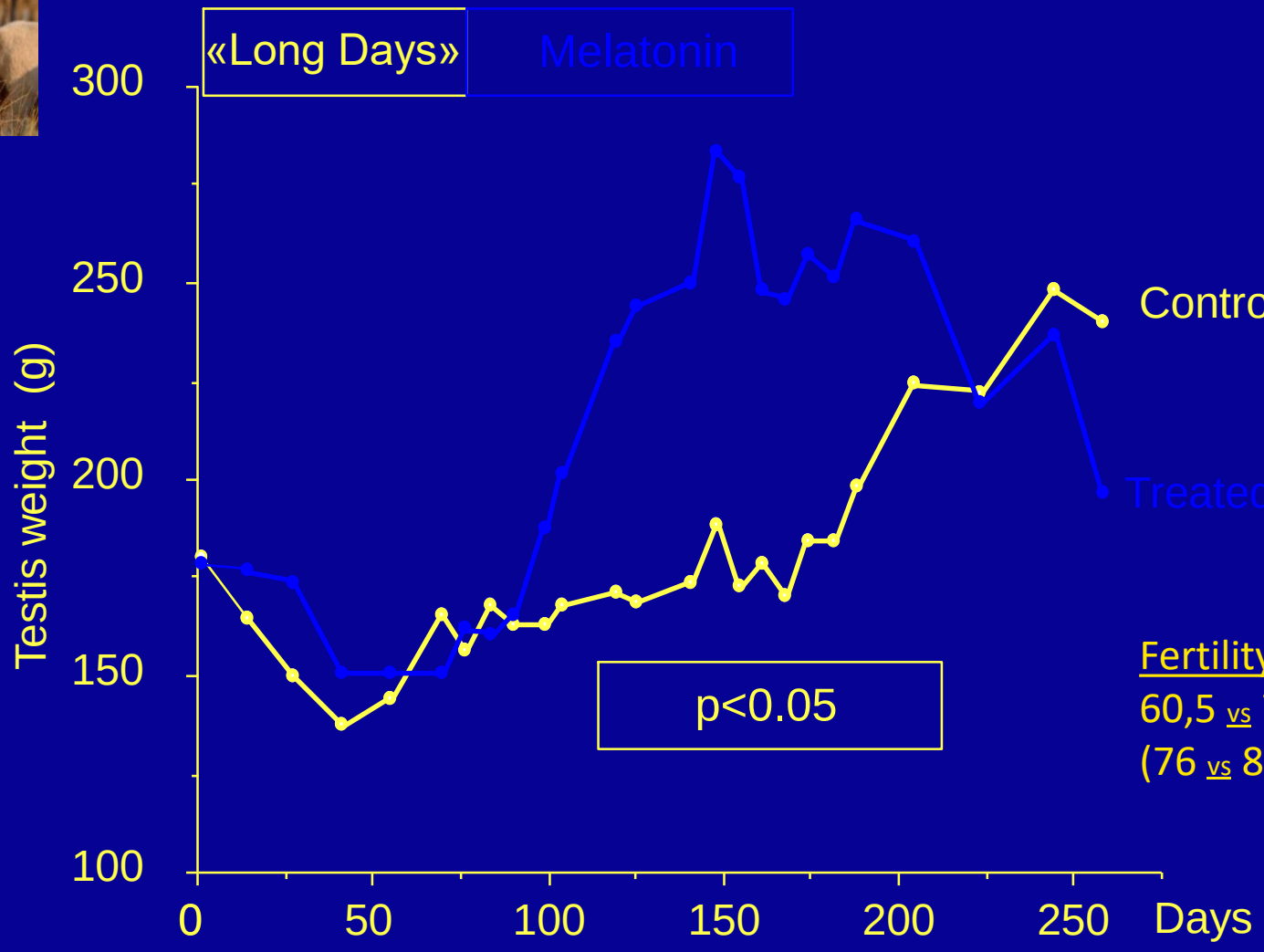
L+M

Control rams

F M A M J J A S

Effects of the treatment light+melatonin on sexual activity of Suffolk rams

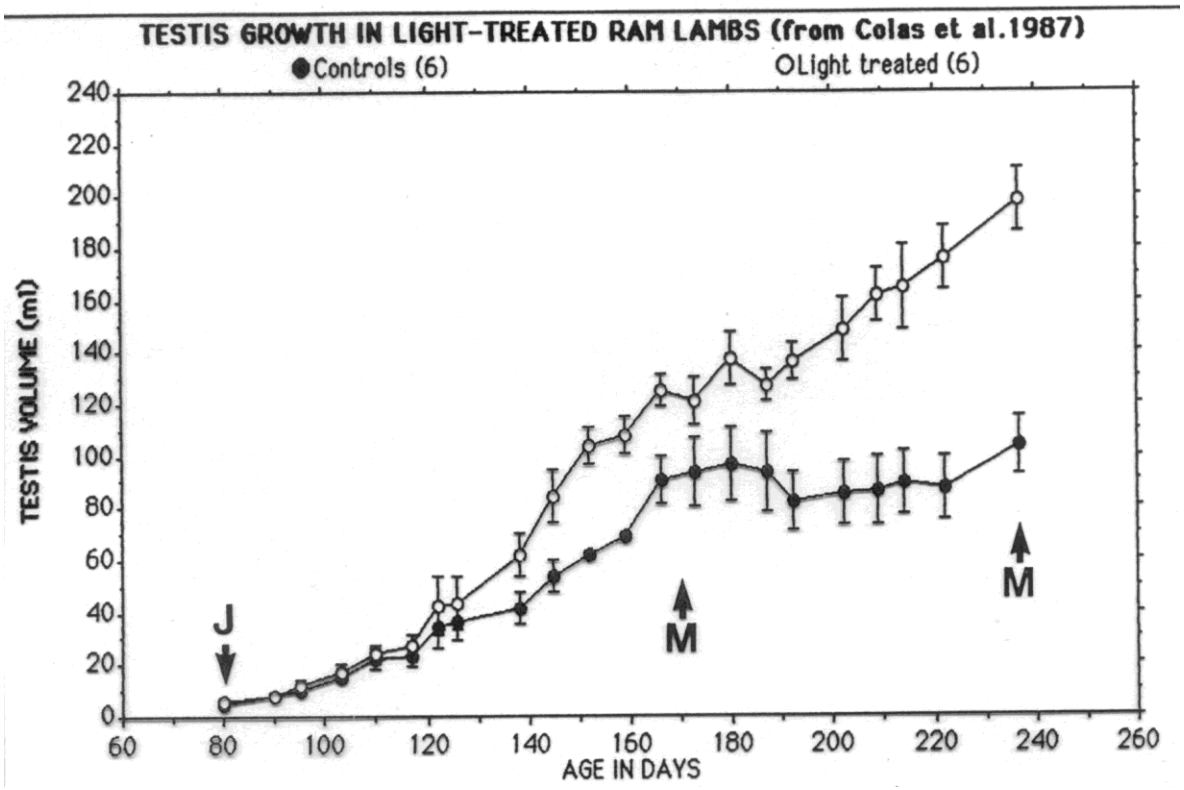
(Williams & Hanif 1989-1990)



Fertility of ewes (AI):
60,5 vs 70,2% (NS)
(76 vs 84 ewes)

Testis weight and semen fertility in Ile-de-France rams control or treated with the succession Light + Melatonin implants
(Chemineau et al., 1992)

Testis growth in Lacaune ram lambs born in november and light-treated or not



Sperm production in Lacaune ram lambs in the Spring after a photoperiodic treatment

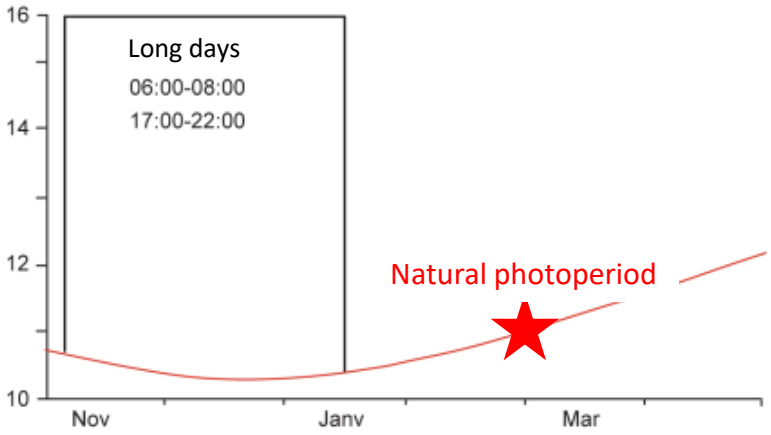
(AI Centers of Rayon de Roquefort, Ovitest and Confédération des Producteurs de Roquefort)

	Control		Treated
Number of ram lambs	43		53
Total number of AI doses produced per ram lamb : (400 x 10^6 spz/dosis, m ±SEM)			
-Center 1 : (total during the collection period)	**29.5 ± 31.8**	p<0.05	**63.3 ± 36.4**
-Center 2 : (per ejaculate)	**11.0 ± 0.5**	p<0.001	**14.2 ± 0.7**

But the most simple treatment is also very efficient :

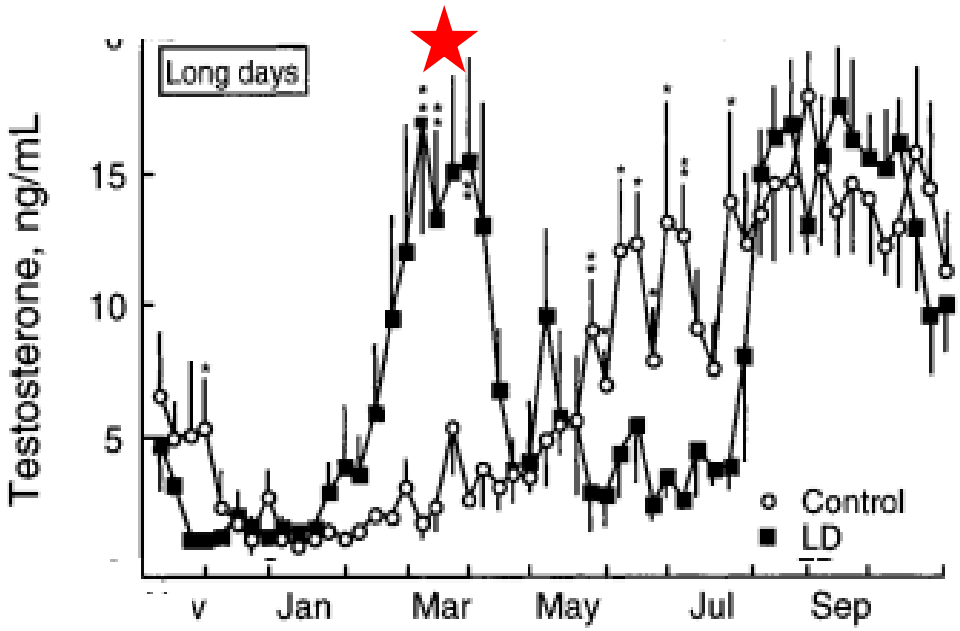
Principle : succession LD -> SD in open barns

- Only 2.5 Months of extra light (16hours) : 1 November -> 15 January
- Without melatonin (NP = SD)
- ★= sexual activity (30 d rams; 45 d bucks)

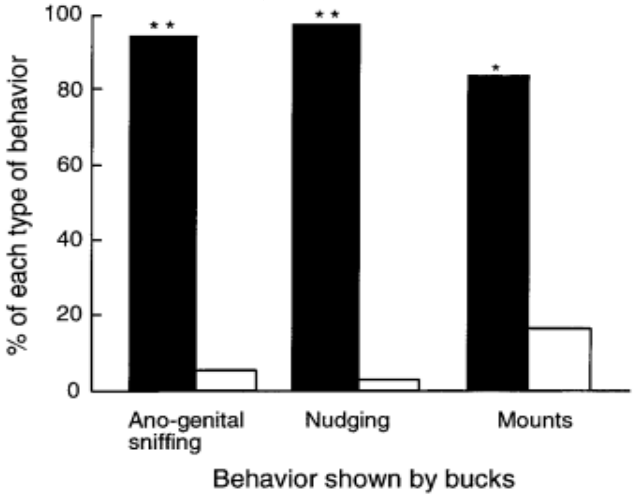


Simple and cheap !

Plasma Testosterone →



Sexual behavior ↘



(Delgadillo et al. 2002)

Sexually inactive male :

Delgadillo JA CIRCA Mex

Sexually active male :

Delgadillo JA CIRCA Mex

3. Semen all the year round

When a real laboratory discovery meets a demand from the professionals

The discovery

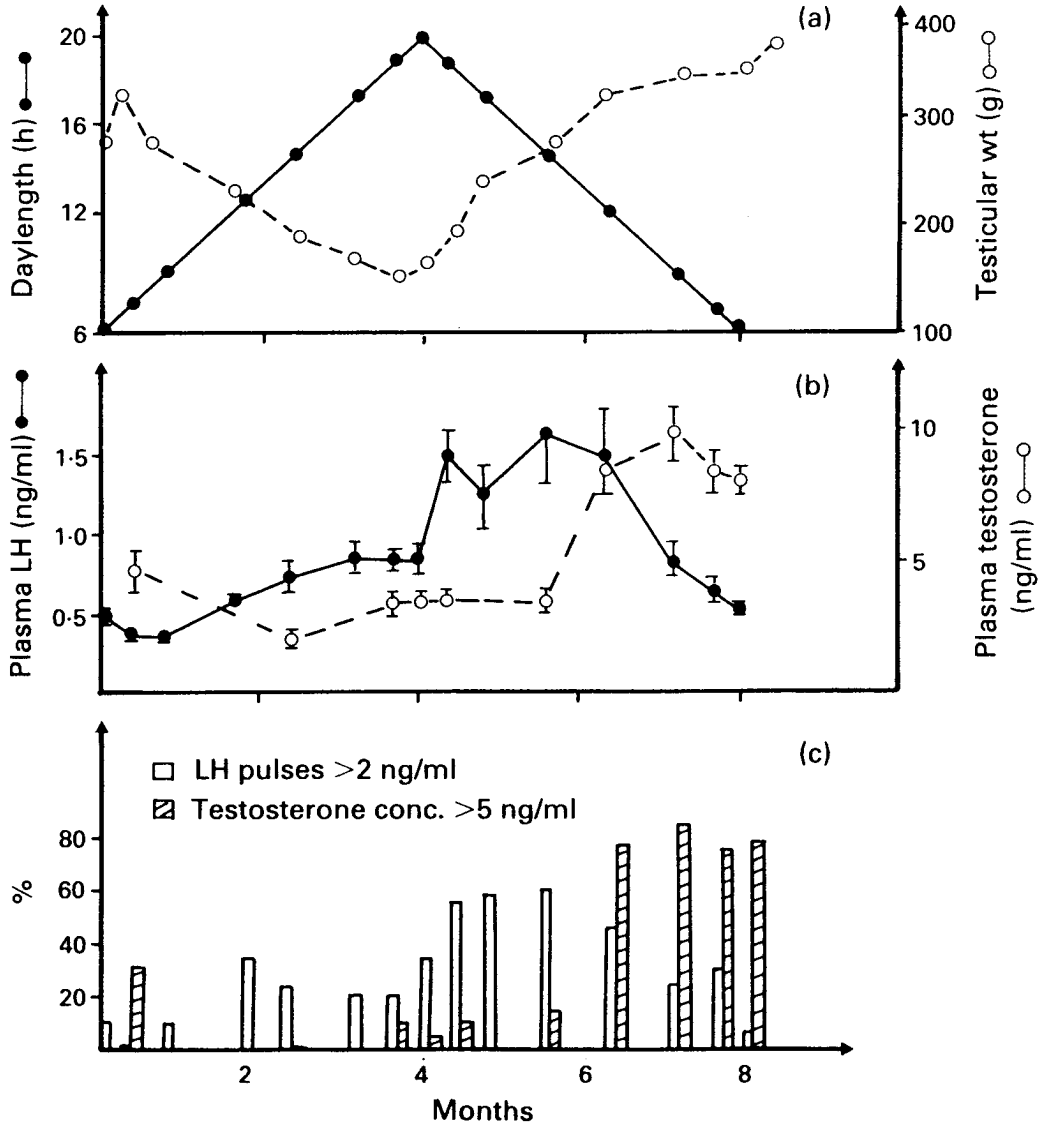
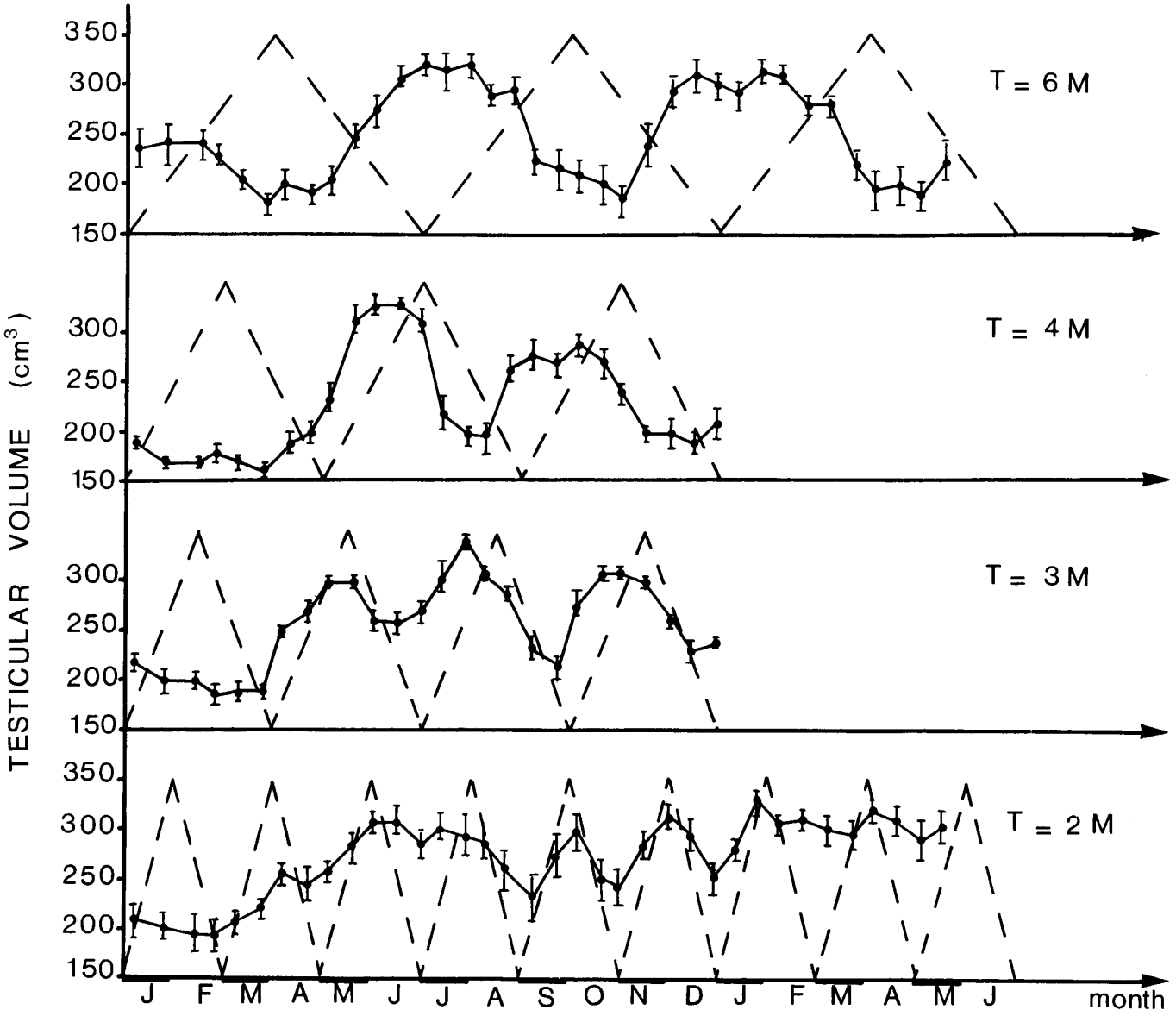


Fig. 2. Daylength variations and cycle of testicular weight (a), mean LH (●——●) and testosterone (○——○) concentrations (b) and frequencies of LH pulses >2 ng/ml and testosterone concentrations >5 ng/ml (c) in rams of Groups I and II pooled.

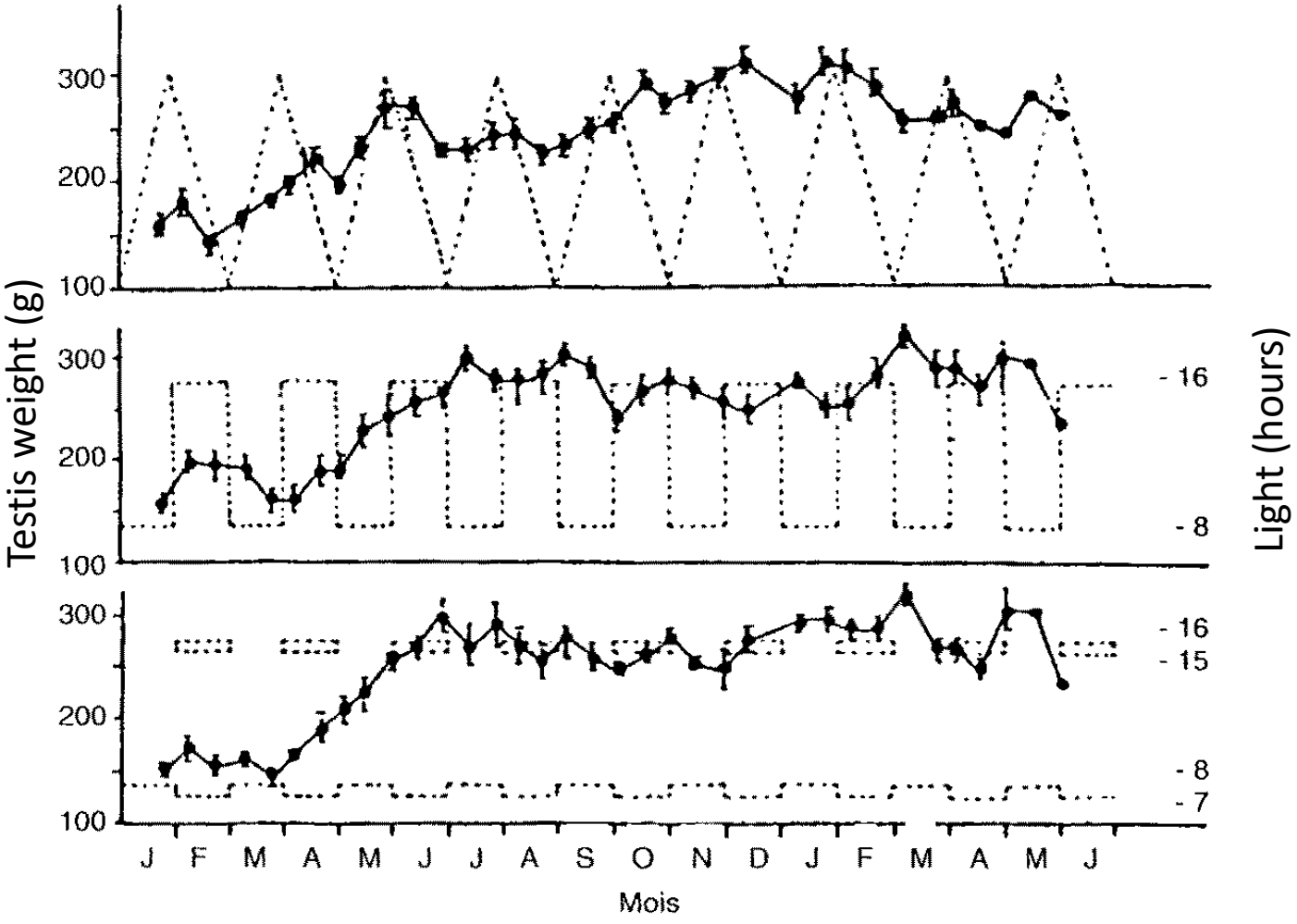
Pelletier et Almeida (1987 - J. Reprod. Fert. Suppl. 34, 215-226)



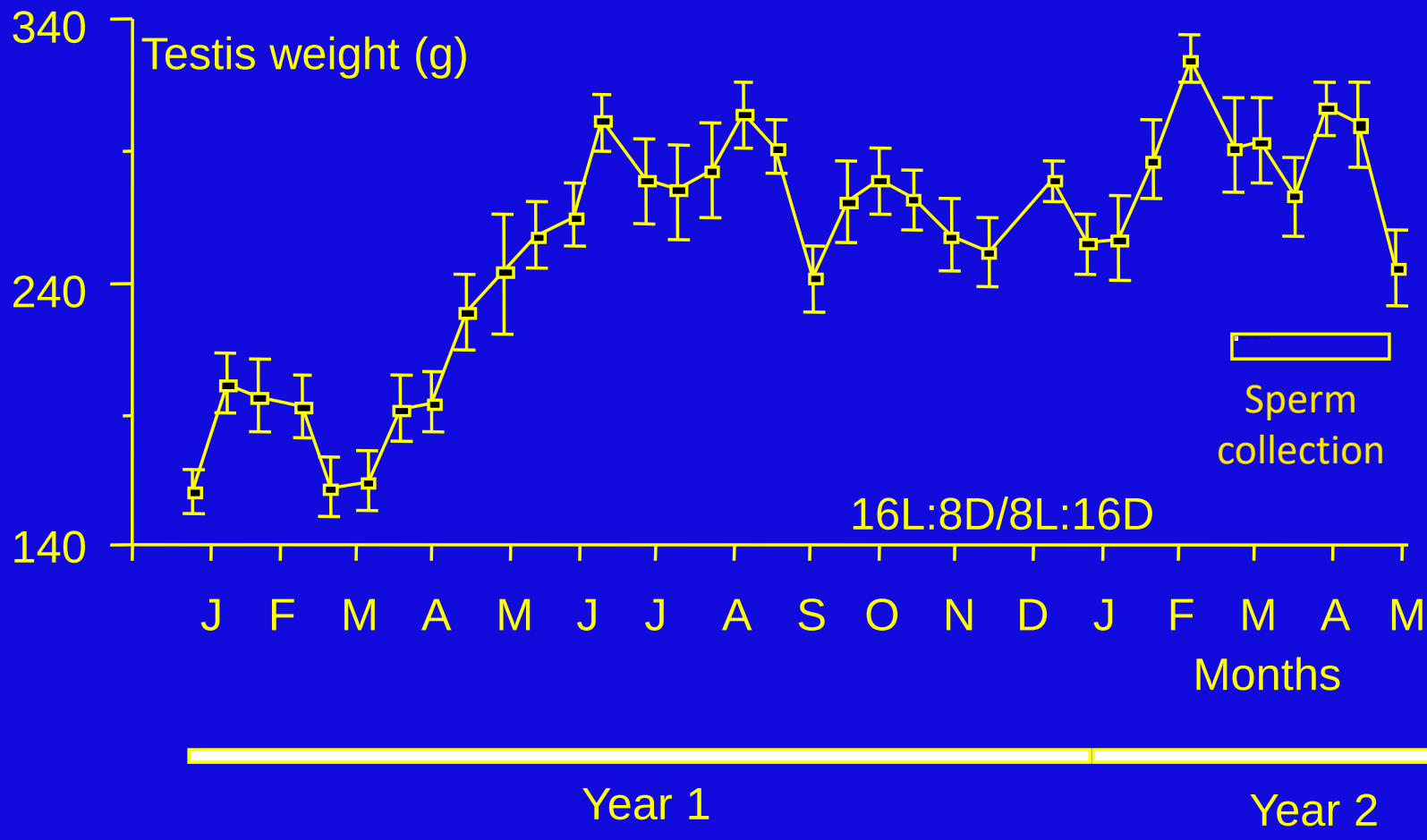
Pelletier (1986)

Effect of different accelerated photoperiodic schemes on the testicular weight of Ile-de-France rams

In light proof barns



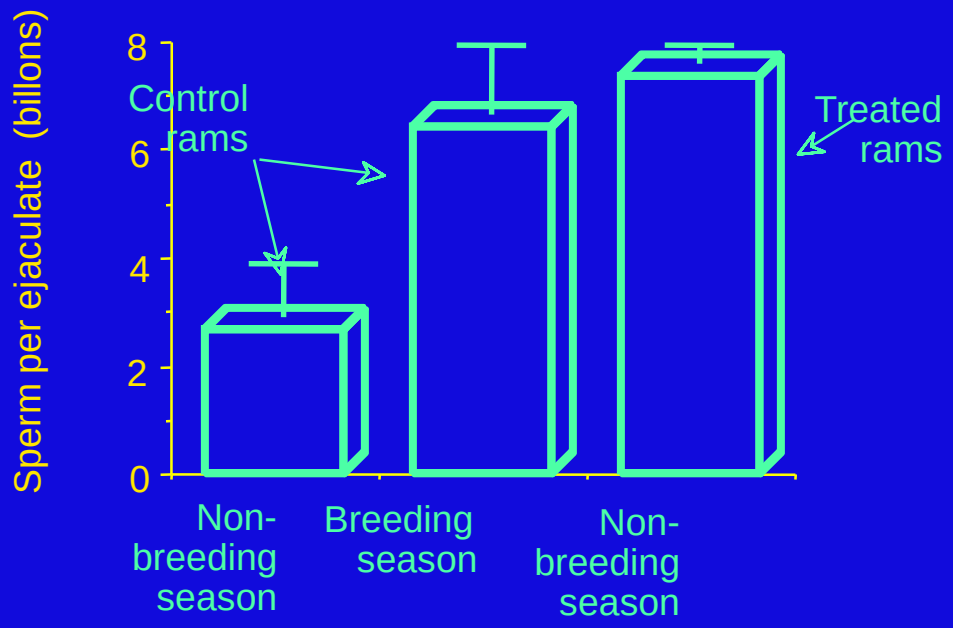
Pelletier et Almeida, 1987

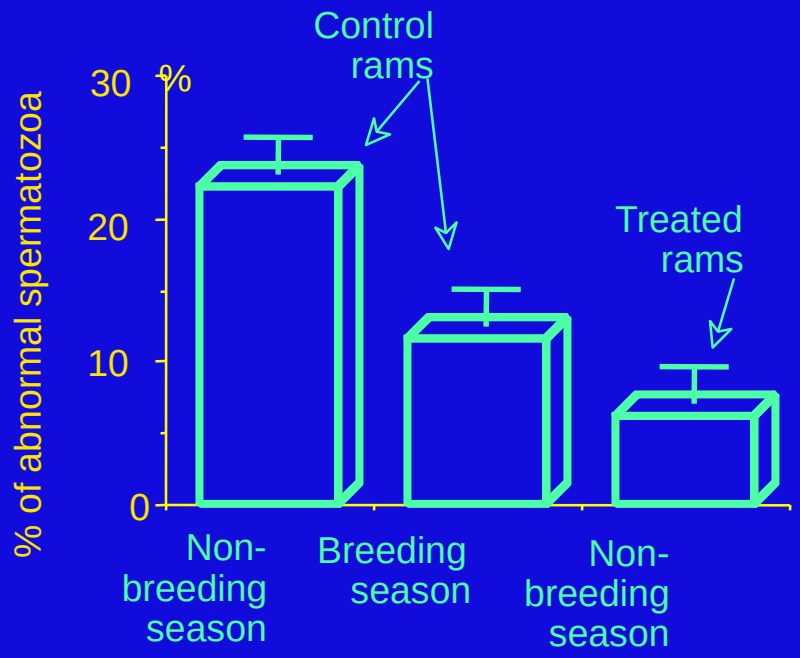


Testis weight of Ile-de-France rams submitted to an accelerated alternation of one month of long days and one month of short days (Almeida & Pelletier, 1987)

Sperm production per ejaculate and percentage of abnormal sperm cells in Ile-de-France rams treated or not with an accelerated photoperiodic scheme

(from Almeida et al. unpubl., in Chemineau et al, 1988)





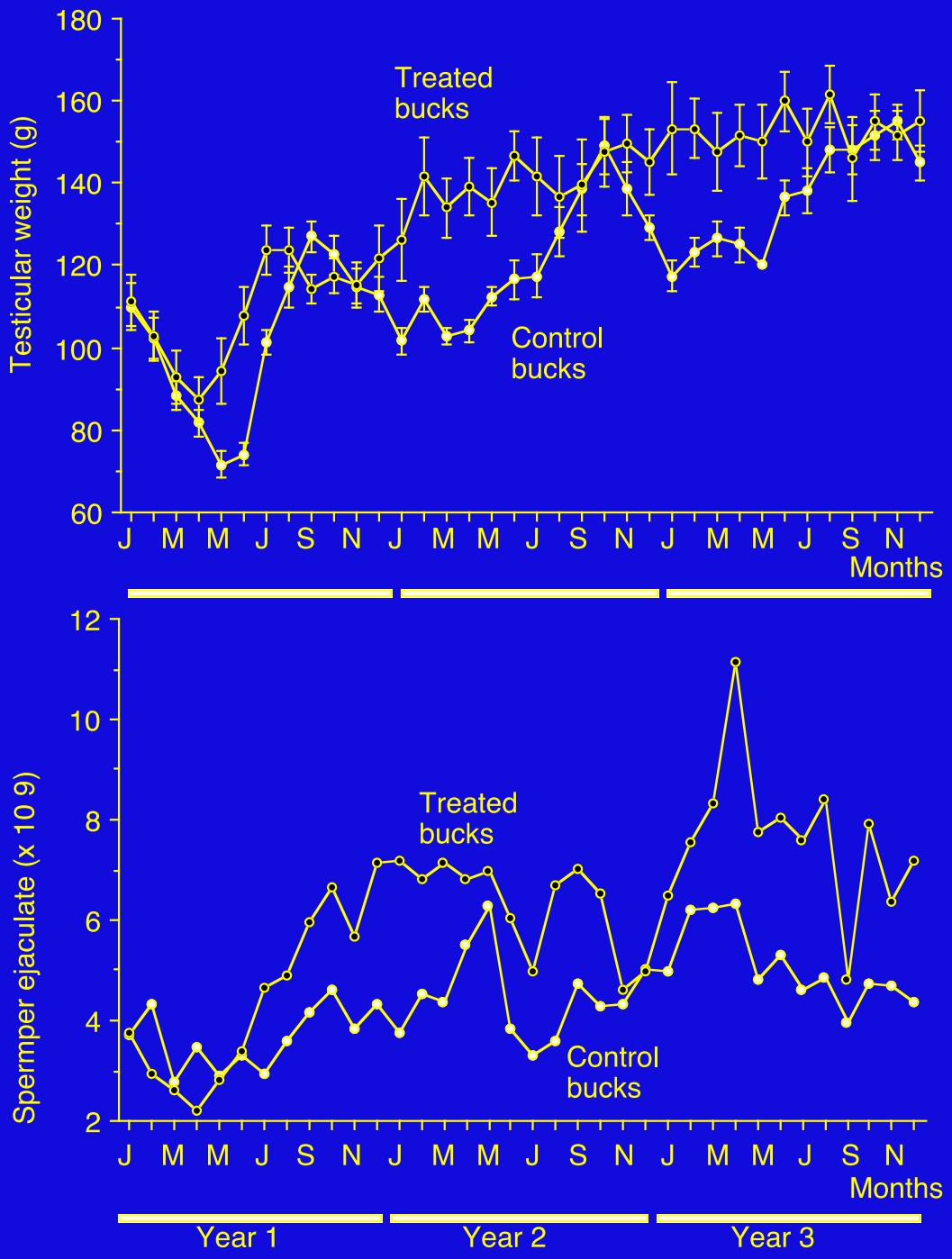
Effect of the accelerated alternation of one month of long days and one month of short days on sperm production in different breeds of rams in AI center conditions (Interselection, l'Aigle)

Breed	Number of rams		% over the control		
	Control	Treated	Usable ejaculates	Spz per ejaculate	Total number spz produced
Rouge de l'Ouest	5	6	+ 5	+ 20	+ 26
Ile de France	4	4	+ 22	+ 27	+ 55
Suffolk	4	5	+ 115	+ 81	+ 290
Charollais	4	10	+ 60	+ 93	+ 209
TOTAL	17	25	+ 50	+ 55	+ 145

P.PEZAVENT et al. 1989

…. This accelerated alternation also works in male goats ……

Testis weight and sperm production of Alpine and Saanen bucks submitted to an accelerated alternation of one month of long days and one month of short days during 3 consecutive years
(Delgadillo et al 1992, 1993)



Accelerated rhythms provoke a spectacular increase in A0 Spermatogonia per testis

Table III. Seminiferous tubules and germ cells parameters of Alpine and Saanen male goats subjected to 2 month (2-mo) and 4 month (4-mo) light cycles or to natural photoperiodic changes and slaughtered during breeding (BS) or resting (RS) seasons (m ± sd).

Parameter	*2-mo*	*4-mo*	*BS*	*RS*
Number of goats	5	4	6	5
Seminiferous tubules				
Total volume (ml)	162 ± 37	143 ± 37	127 ± 40	87 ± 7
Length/testis (m)	2 175 ± 372^{a}	2 206 ± 591^{a}	2 136 ± 664^{ab}	1 596 ± 127^{b}
Mean diameter (µm)	250 ± 19^{a}	230 ± 19	221 ± 15^{c}	211 ± 11^{c}
Lumen mean diameter (µm)	47.8 ± 7.6	48.3 ± 5.6	45.0 ± 5.7	41.8 ± 4.4
Sertoli cells				
Total No/testis (x 10^{8})	17.1 ± 4.2^{a}	18.2 ± 4.9^{a}	15.4 ± 6.3^{a}	14.0 ± 2.1^{a}
Nuclear area (µm^{2})	70.9 ± 9.7^{a}	79.1 ± 7.6^{a}	79.0 ± 13.0^{a}	69.8 ± 5.6^{a}
Germ cells				
Total number				
A0 spermatogonia/testis (x 10^{8})	2.6 ± 1.2^{a}	2.5 ± 1.5^{a}	1.4 ± 0.7^{b}	1.6 ± 0.5^{b}
Daily production/testis				
A1 spermatogonia (x 10^{7})	3.1 ± 1.5^{a}	2.9 ± 1.5^{a}	2.9 ± 1.3^{a}	1.6 ± 0.2^{b}
Leptotene primary spermatocytes (x 10^{9})	0.9 ± 0.2^{a}	0.9 ± 0.2^{a}	0.9 ± 0.3^{a}	0.4 ± 0.1^{c}
Round spermatids (x 10^{9})	2.3 ± 0.3^{a}	2.0 ± 0.6^{a}	2.2 ± 0.6^{a}	1.3 ± 0.2^{c}

For each parameter, numbers with different superscripts differed significantly (a ≠ b: $P < 0.05$; a ≠ c: $P < 0.01$).

(Delgadillo et al. 1995)

Natural *vs* accelerated photoperiod
Production of AI doses

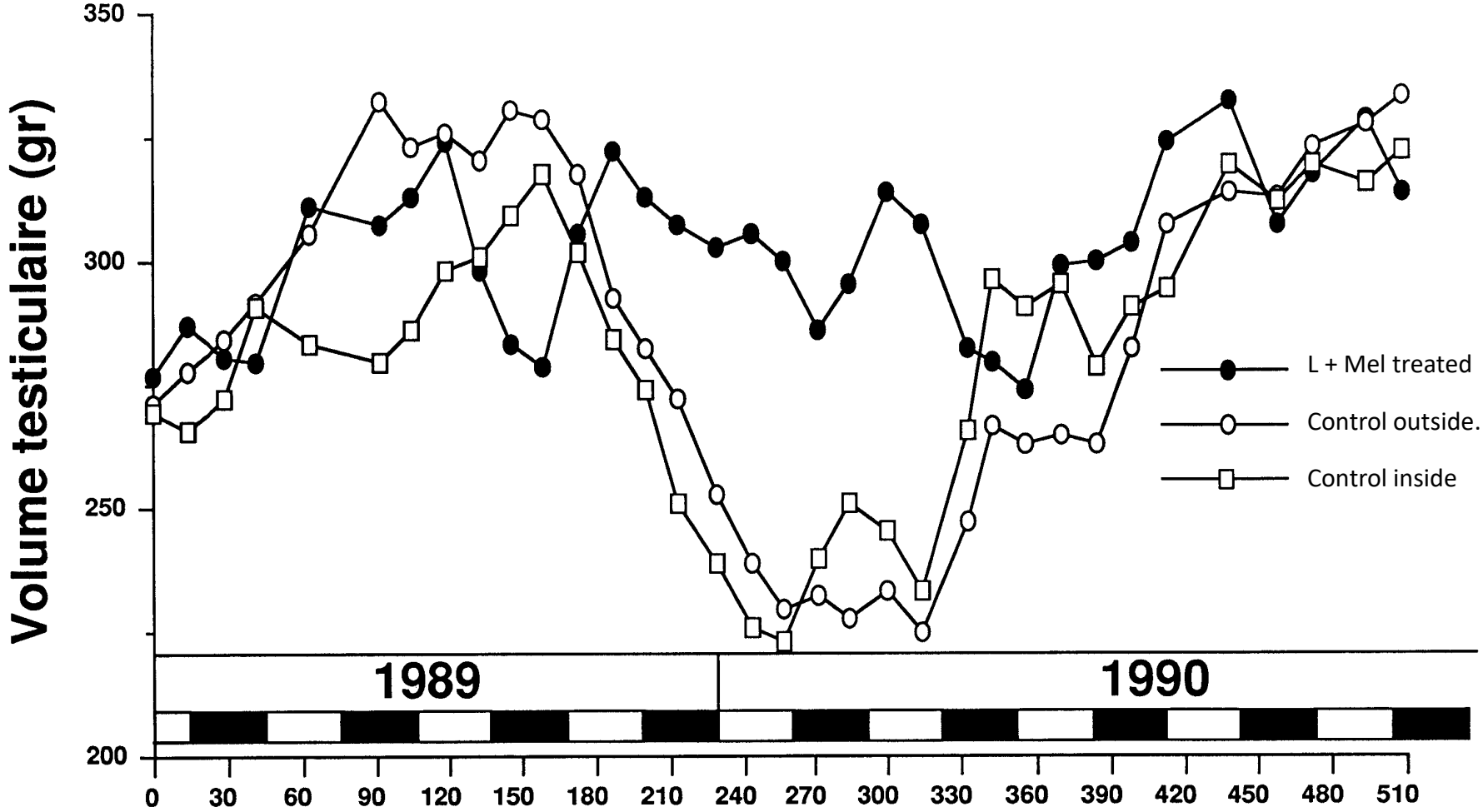
	Control bucks Natural Photoperiod	Treated bucks (45 LD / 45 SD)
Rhythm of collection : 4 collections per week	Breeding season (6 months)	All year round
Number of AI doses per year	1 106	1 655 (+33%)

(Chemineau et al., 1999)

All bucks of the French breeding scheme
(~ 70 per year)
are actually treated
(since > 20 years)

….. can it be done in open barns ? …..

Effect of the alternation of 1 month long days/ 1 month Melatonin implants on the testicular weight of Ile-de-France rams in open barns



Melatonin implants

« Long days »

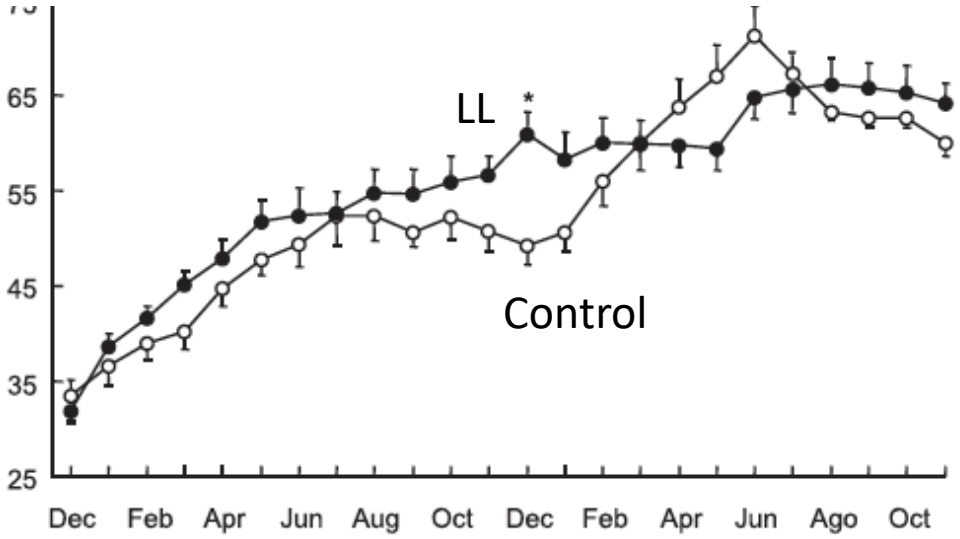
(Pelletier et al. in Delgadillo et al. 2024)

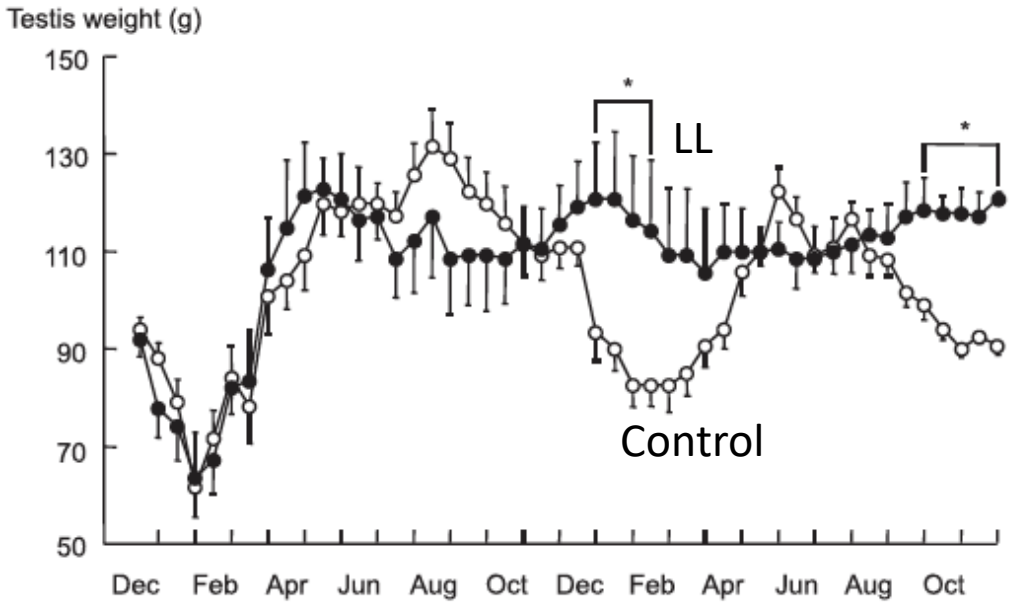
=> Yes, but difficulties to remove the implants

Effect of the alternation of 1 month long days/ 1 month permanent light (LL) on body and testicular weights of Mexican Creole bucks in open barns

<u>NB1:</u>
- LL = SD
- LL = Melatonin

(Delgadillo 2016
Chesneau 2017)





=> It can be done in open barns

NB2: Permanent light is prohibited in Europe

(Delgadillo et al. 2024)

Conclusions

1. Seasonal variations induce low sexual behavior, low sperm quantity & low fertility when farmes (and us) need them
2. Photoperiodic treatments are very efficient for:

- Spring and Summer sperm production
- Producing semen all the year round

3. They can be used in light-proof barns as well as in open barns

Thanks to :

José Alberto Delgadillo

Universidad Autónoma Agraria Antonio Narro, Torreón, Coahuila, México

José Alfonso Abecia

Departamento de Producción Animal y Ciencia de los Alimentos, IUCA, Universidad de Zaragoza, Zaragoza, Spain

Thanks for your attention

…. any question, comment ?

AI in sheep and goats in France

Species	Aim	National flock (females)	AI number /year	Season	Semen processing	Total spz x 10^6 (0.25ml straw)	Fertility (%)	Price (€)
Sheep	milk & meat	5 329 000	**633 000***	spring-summer	liquid	**300**	**61.8**	12
Goats	milk	933 000	**65 500**	spring	washed & deep-frozen	**100**	**56.2**	30

(data 2020 or 2022*)

(Chemineau 2024, from IDELE 2023)