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Chapter 2

Some Peculiarities of Horse Breeding

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Additional information is available at the end of the chapter

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1. Introduction

There are approximately 60 million horses in the world, most of them living in America, Asia and some European countries. Currently China has the largest herd (around 8 million), followed by the United States (7 million), Mexico (a little more than 6 million) and Brazil (a little less than 6 million). Together, these four countries have close to 45% of the world's equine population [1].

The horse population's growth rate has been either constant or decreasing in most of the countries, with only some regions in Central America, Asia and Europe keeping positive growth rates (Figure 1). From 2003 to 2007, Puerto Rico presented the highest growth rate (45.4%), while the biggest Decrease was in Benin, Africa (-12.9%) (Figure 2).

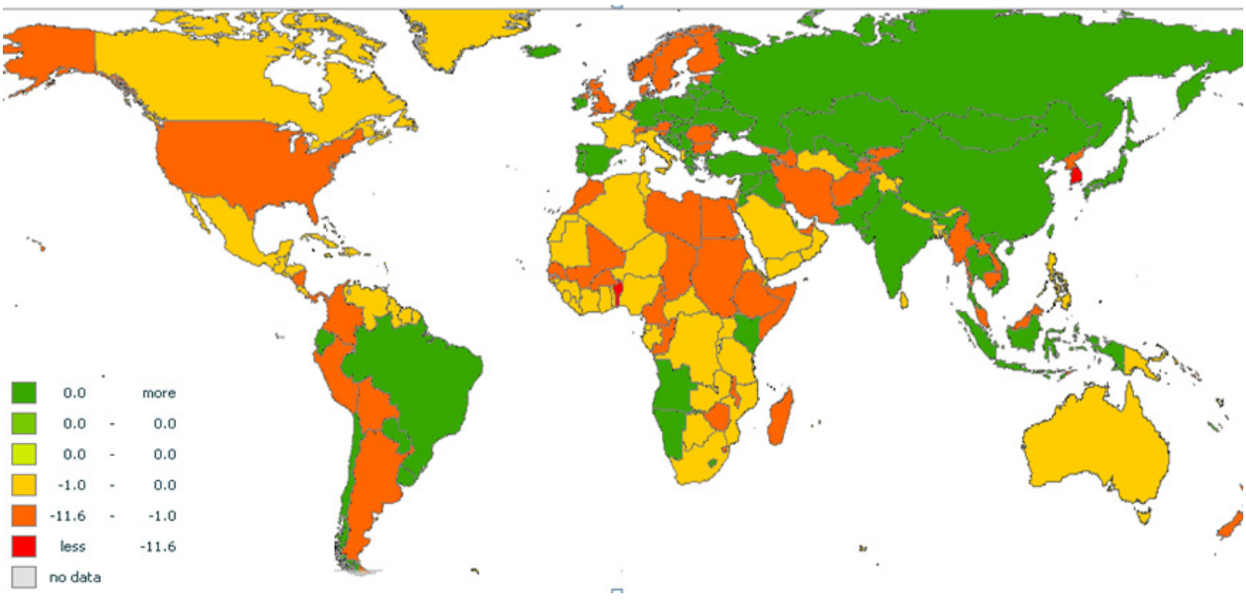


Figure 1. Growth rate of horse population in the world from 1997 to 2007 (Source [1])

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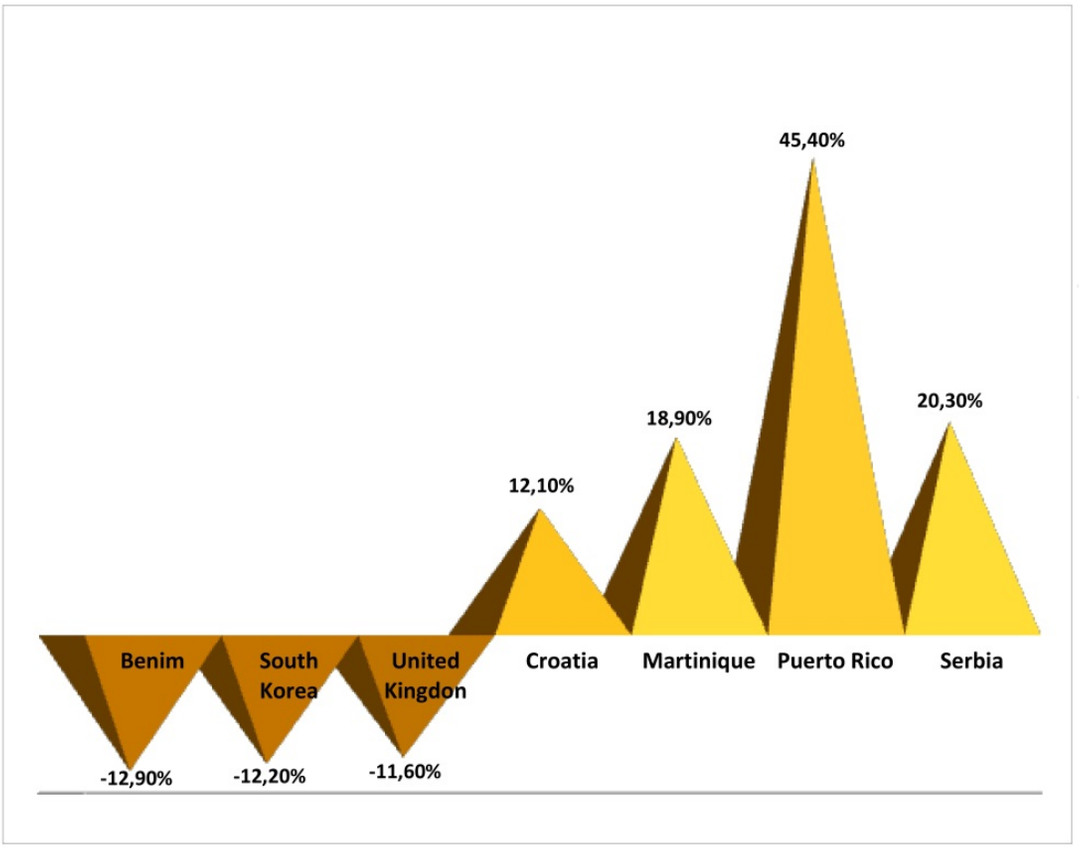


Figure 2. Countries with higher and lower equine population growth rates from 2003 to 2007

The world's export trade of live horses is concentrated in Europe and America, together representing 84% (58% and 26% respectively) of 2.1 billion dollars moved around yearly [2]. According to this source, the United States were the main exporter (148,472 animals, representing 48.8% of the world trade), raising around 474 million, in average $ 3,200 per animal.

Similar to the exportation, the world trade of live horses in relation to imports is highly supported by Europe (49.8% of the world trade), followed by Asia (26%) and Mexico (82,854), Canada (63,240) and Italy (46,333) are the main importers in number of animals, although the highest global expenditure in this aspect occurred in the United Kingdom (U.S. $ 498 million), UAE ($ 236 million) and Ireland (U.S. $ 233 million), representing together 46% of annual turnover - [2].

2. Horse breeding

The expression "improvement of equine species," according to [3] dates back to the French articles about horses and donkeys in the*"Histoire Naturelle"* by Buffon in 1753. Despite the strong creationist dogmas of that time, these articles anticipated evolutionist ideas, while they described the concept of race degeneration due to the influence of location or climate. Adopted by the French Veterinary schools, it was believed that in order to return to an ideal type of creation, it would be necessary to mate mares and stallions with opposite types, to

compensate traits that differed from the ideal. This meant basically to look for stallions on distant lands or regions.

Only decades later, after Darwin's evolution theory introduced the concept of selection is that the improvement of native populations emerged to counterbalance the situation, and effectively replace the desire to keep local types. Later, and gradually, the management of purebred animals predominated over crossbreeding, ending in the Thoroughbred Studbook's creation (first worldwide). It was a very important step for the use of animal production techniques in the 19th century [4]. According to the author, these techniques required precise identification procedures records of races held at different times and places in order to relate them to the same horse. The Stud Book, from the animal lineage certification, not only made it possible to relate the own horse performance information, but also their relatives. This fact prepared the way for the pedigree selection and progeny tests.

In addition, until the beginning of last century, horses were the focuses of experimental tests of inheritage theories. In this sense, historically the main concepts introduced by the horses, especially by the Thoroughbred breed, were [4]: performance selection in a purebred, introducing of a precise method for identifying an animal and its relatives, thinking about the male and female roles in the herd and the widespread use of planned matings.

Currently, although research in several countries are published every year in the literature involving some kinds of horse breeding study, few of them have ongoing consistent selection program. It means, in a way that most of research results in this area don't generate practical application and therefore it adds little to the species' development.

In most cases, this fact occurs because the breeders don't show interest in using the research results and not because of the research quality. The studies, depending on the availability and quality of information, usually do not consider the breeders' interests. Thus, in most countries there is wide gap between research institutes / universities and breeder associations. This gap is particularly due to the fact that more than in other species, horse breeders consider other breeders as potential competitors and give little importance to joint actions needed in breeding programs.

On the other hand, closer relation in Japan, Canada and some European countries, have allowed major advances in horse breeding. In Germany, for example, a country that stands out for jumping and dressage competitions and export of horses, the opinion, awareness and cooperation among breeders gave associations set guidelines that would meet not only their needs, and those of the research institutes / universities, but also the interest of the country. So the Breeders' Associations, supported by these institutions, publishes annually a Sire Handbook containing productive traits considered of general interest. This liaison has been very productive, resulting in19 gold, 8 silver and 12 bronze medals only in the last two Olympics[1], besides over 50 medals in some recent world championships [5].

[1] taking into account dressage disciplines, jumping and eventing.

3. Some advantages and difficulties in horse breeding

Comparing to other farm animal species, there are some advantages and difficulties specifically related to researches on horse breeding, when quantitative genetics principles are used.

The advantages are fundamentally the amount of performance information and pedigree extension.

- The depth of the genealogy in most breeds is high

Traditionally, horse breeders associations consider the "pedigree" as a key factor to select their animals, so that in most of them, herd control is efficient. This fact goes back to the world's first Stud Book opening in 1791 (General Stud Book) for Thoroughbred animals. It was the basis for the other *Stud*Books, not only for horses, but also for all other domestic species.

Most of the breeds that were studied based on breeding, it is possible to track the animal's genealogy back to the fourth or fifth generation (depending on when the breeders' association's started), so that genetic evaluations in this aspect are efficient.

- Economic important traits can generally be measured in both genders.

In most of the breeds, especially the ones for some kinds of performance, the possibility of measuring both genders generates a greater information and knowledge volume about the behavior of traits in the population, what enables more efficient genetic evaluations. Racing, jumping, dressage, barrel, performances[2] are examples of this kind.

On the other hand, even in breeds (or strains within a breed) where the breeding economic interest is the production of animals only for the conformation, not for performance, both genders can be evaluated.

- Economic important traits can usually be measured repeatedly in short time periods.

In horses it is possible to get repeated performance in relatively short time periods in a large portion of the population, while that doesn't happen with some domestic species, where economic important traits aren't repeated in the animal life (weight at weaning, weight at the year), or require a relatively long time to repeat (milk production, weight of the fleece).

In this sense, considering that the average number of starts per horse in Thoroughbred race season 2007/2008 was 6.5 [6], in a year is possible to get reasonable performance information (position, awards, time) about the horses. Although this average represents a new performance every two months, there are animals that race every 15 days, or even during the same week.

On the other hand, certain difficulties related to equine species and others due to various issues have been some of the major problems when research on horse breeding is done.

[2] meets three classical disciplines: dressage, cross country and jumping. It is a form held in three days.

3.1. Inherent to the species

- Low reproductive rates

Since the early ancestors emerged from 55 to 60 million years ago, horses are adapting in order to develop a reproduction model that ensures survivability in the wild, adopting different reproductive strategies to ensure that their progeny are born in the appropriate time of year [7]. However, domestication has strongly influenced reproductive performance, with selection pressure on fertility being either small or null, and mating usually dictated by the functional performance of the animals [8].

Thus, considering that reproductive traits usually have low heritability estimate [8], and have been selected on horses by an indirect way, genetic alterations in order to enhance characteristics of this nature are evidently neither fast nor simple, especially in a species with a long generation interval such as the equine's (see item "High ranges of generation and delivery").

Hence, horses have low reproductive performance when compared to other farm animal species. The birth rate ranges from 59% [9, 8] to 74% [10, 7] the higher percentages being usually found in tests involving a small number of mares. Table 1 illustrates the result of 42,750 matings done with 7,278 Thoroughbred mares. It was observed that birthrates for males and females were 49.26% and 50.74%, respectively, whereas abortion and stillborn foals were 1.41% and 2.02%, respectively. It was also recorded that 9.07% of coverings were classified as empty, whereas 23.7% of matings did not show any latter records to track success.

Occurrence	Number of observations and %
Male	(29.35%)
Female	12,927 (30.23%)
Abortion	603 (1.41%)
Empty	3,878 (9.07%)
Without information	9,864 (7.23%)
Stillborn	866 (2.02%)
Not mated	1,945 (4.54%)
Mated with another breed	135 (0.31%)

Source: [8]

Table 1. Occurrences after mating

This relatively low fertility is described in different races, countries and purposes, and may be related to hormonal dysfunction, genital infections in mares, parasitic infestations and inadequate handling practices before the breeding season [11]. These factors are even more imposing in the case of animals used in sports, since they have very different handling from those that are exclusively used in breeding [12]. Furthermore, maintenance of older mares and stallions due to their progeny's superior sporting performance can decrease the rate of

conception in the herd, as the rate decreases progressively with increasing age [13]. Table 2 describes this aspect, illustrating the conception and apparent fertility rates (defined by [14] as the ratio of the total number of mares that conceived by the total number of mated mares and as mares that delivered living foals by the number of mated mares, respectively) according to parturition order.

Parturition Order	N	Conception rate (%)	Apparent fertility rate (%)
1	5.531	75	71
2	4.534	73	68
3	3.655	71	68
4	2.794	69	67
5	2.155	67	65
6	1.560	64	61
7	1.070	62	59
8	777	59	56
9	513	56	54
10	329	54	52
11	171	48	47
12	92	48	46
> 13	79	41	38

Source: [8]

Table 2. Number of observations (N), conception rates and apparent fertility according to the parturition order of Thoroughbred mares.

Additionally, in some breeds (Thoroughbred, Quarter Horse, Standardbred, etc.), the existence of the so-called Racing Year[3] also contributes to the decrease in reproductive rates. This is because, in certain competitions, animals are usually grouped according to, among other parameters (awards, past performance, gender, etc.), the horse's age defined by the racing year. Thus, breeders try to get the products born closer to the beginning of the equestrian year (July 1st - southern hemisphere or January 1st - northern hemisphere) in order to seize a competitive advantage (better developed, mature and trained horses) in relation to the animals born later that year [15]. Figure 3 shows the concentration of births of Thoroughbred foals in Brazil, a country located in the southern hemisphere.

[3] In the southern hemisphere, an interval of 12 months between July 1st and June 31st. In northern hemisphere countries, begins on January 1st and ends in December 31st.

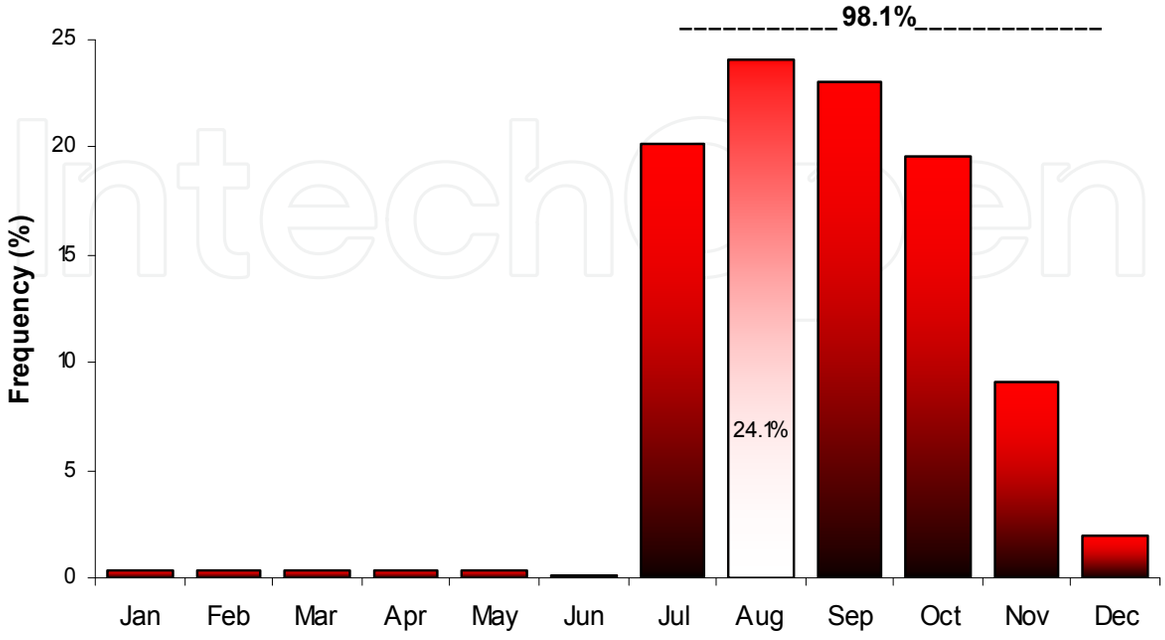


Figure 3. Percentage of Thoroughbred foal births by month in Brazil

With that objective, the breeding season, that usually lasts for 4 to 5 months, usually starts in August 15th in the southern hemisphere (or February 15th in the northern hemisphere). However, the percentage of mares that naturally ovulate in this period is quite low, since mares are seasonal poliestric, with the onset of the natural breeding season in spring, associated with increases in photoperiod, temperature and food availability [7]

In this sense, [15] found in Thoroughbred horses raised in Ireland (Northern Hemisphere), that the change of the beginning of the breeding season from February 15th to April 15th (hence delaying the beginning of the racing year by the same amount - January 1 to March 1), would better accommodate the natural reproductive cycle of females and could potentially increase the pregnancy rate by approximately 10% (Figure 4). Similar gains were likely to occur in countries in the southern hemisphere if the beginning of the breeding season changed from August 15th to October 15th, consecutively postponing the beginning of the racing year from July 1st to September 1st. Following this guidance, Australia postponed the beginning of the national racing year to August 1st (breeding season between September and December), mitigating the problem, although [13] considers the best breeding season in that country to be between November and February.

Figure 5 helps to understand the idea suggested by [13], as it represents the photoperiod in the southern hemisphere according to the latitude. It is observed that photoperiods are longer between October and February and higher percentages of ovulating mares are expected, favoring successful coverings.

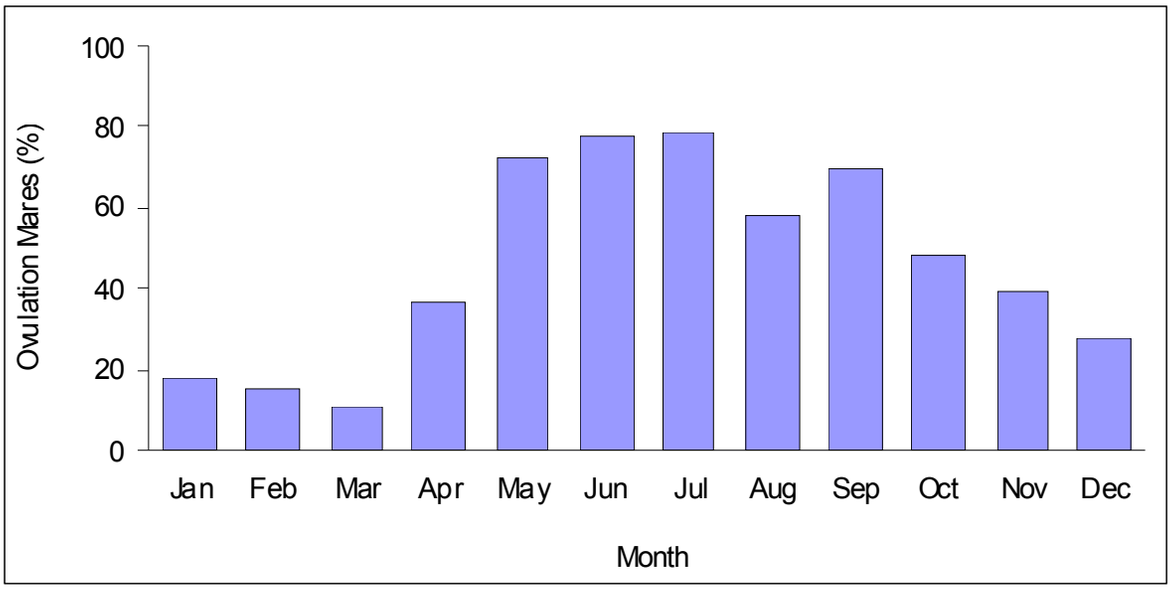


Figure 4. Percentage of mares ovulating by month in the northern hemisphere (adapted from [15])

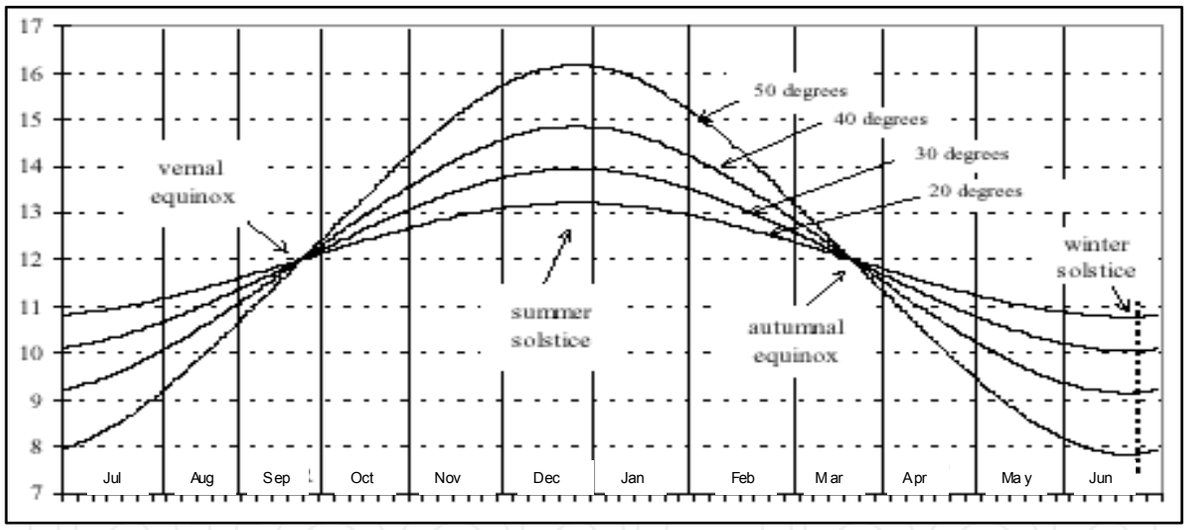


Figure 5. Photoperiods for different degrees south latitude (adapted from [16])

- high generation and parturition intervals

Generation interval represents the time needed to replace the next generation, and the shorter it is, the greater the expected annual gene change rate. Thus, considering that in horses this interval varies from 8 to 12 years, overall genetic changes due to selection tend to be slower when compared to cattle (4-6 years), sheep (3-5 years) pigs (1.5 to 2 years) and birds (1 to 1.5 years). Sportive breeds, in which reproductive technologies are not permitted, typically show higher ranges as the superior performance animals, especially females, usually start into reproduction after the end of their competitive life.

The generation intervals of some equine breeds are described in Table 3.

Breed	Generation Interval (years)	Reference
Andalusian	10.1	[17]
Thoroughbred	7.10	[18]
Icelandic Toeler	9.7	[14]
Friesian	9.6	[19]
Hanoverian	8.4	[20]
Mangalarga	9.5	[21]
Arabian	9.7	[22]
Lusitano	10.5	[23]
Mangalarga Marchador	8.9	[24]

Table 3. Generation intervals from a few equine breeds

The parturition interval is the amount of time between two consecutive parturitions, including the time from the parturition until the appearance of the first heat, from the first heat to the conception and finally the duration of pregnancy. It is an important component when estimating the herds' reproductive efficiency, with great influence on the economic return and breeding, due to its effects on the generation interval and selection intensity to be applied.

Among the domestic species, the mare has the capacity to provide fertile estrus a few days after birth, the so called foal heat. The main advantage of this phenomenon seems to be the maintenance of a 12 months foaling interval [25]. According to these authors, due to the enrollment of horses in sport activities, there is great pressure in order to have as many pregnant mares as possible in the breeding season. In this sense, efforts are made to cover mares in the foal heat. Considering the average pregnancy lasting around 11 months (see topics below) and the possibility of new pregnancy in the close postpartum days, a 12 months foaling interval would be obtained [25]. Thus, most breeders seek to take the opportunity of the foal heat, being aware that during this heat mares ovulate quickly, conception rates are lower and early embryonic mortality rate is higher [8].

There is a great variation among the equine foaling intervals, depending on the breed and breeding purposes, although most studies point values greater than 365 days (Table 4).

Breed	Foaling interval (days)	Reference
Halflinger	468	[26]
Thoroughbred	490	[8]
Marwari	535	[27]
Kathiawari	567	[27]
Mangalarga Marchador	548	[24]
Arabian	387	[7]

Table 4. Foaling intervals in some equine breeds

- Relatively long gestation period and low number of offspring per parturition

Although the duration of a pregnancy isn't directly associated with a breeding farm's production costs, its study may be extremely important in the preparation of breeding plans.

The gestation period can be defined as the time between fertilization of egg and the fetus' delivery. According to [28], the average duration of a mare's pregnancy is typically 340 days, ranging from 300 to 400 days. This wide time range until the birth of the foals indicates that mares may be highly susceptible to both internal and external factors afecting the duration of the pregnancy [29]. The ages of mare and stallion, year and month of birth, breeding season, foal sex, breed and nutritional status are factors that should be considered in the study of the pregnancy's duration [28].

Studies focusing the stallion used on coverings also deserve special attention when studying the pregnancy period in mares. The pregnancy's duration for females mated with specific stallions may be a criterion when choosing the stallion. This is because when a mare is bred late in a breeding season, yet the owner wants to mate her during this season, choosing a stallion associated with shorter pregnancy durations may be profitable [28].

Working with horses in the northern hemisphere [30] observed that the mating season was the most important factor affecting the duration of pregnancy in mares. According to these authors, the pregnancies that derived from mating during the period from December to May were 10.4 days longer than those derived from mating from June to November.

Studying Arab mares in Egypt, [31] observed that pregnancies with longer durations were the ones that ended in the winter, suggesting that the mares seem to be able to adapt the length of the gestation so the births happen in spring, which may be important for the survival of the species in the wild.

Breed	Gestation period (days)	Reference
Carthusian	332	[32]
Thoroughbred/Quarter Horse	341	[33]
Andalusian	336	[34]
Standardbred	349	[35]
Mangalarga Marchador	327	[24]
Arabian	334	[7]
Criollo	335	[36]
Freiberger	336	[37]

Table 5. Gestation periods in some equine breeds

Regardless of the discrepancy between studies and breeds, mares have a relatively long gestation period compared to other domestic species such as cattle (270-290 days), goats (145-151 days), sheep (144-152 days), pigs (112-115 days) and buffalo (298-317 days). Furthermore, as a uniparous species, twins (or multiple) are rare in mares, incidence varying from 0.5 to 1.6% of parturitions [38], so that the annual availability of animals for selection is comparatively small.

3.2. Other aspects

- Use of reproductive technologies

Although reproductive technologies (artificial insemination and embryo transfer) make possible different practical advantages such as lower disease and injury transmission, long-term storage of genetic material, easier transportation, earlier onset of reproduction in females and, in the case of embryo transfer, reproduction during the sports career, in the context of animal breeding they are usually considered additional tools to optimize breeding programs [5].

The commercial impact of these techniques in horses varies greatly. For example, in Thoroughbred horses meant for racing, the use of artificial insemination[4] is officially banned worldwide, while in several sportive breeds, especially in Europe, the percentage of inseminated animals exceeds 80% (French Saddle Horse - 84%, Hanoverian - 91% Holsteiner - 95%, Belgian and Dutch Warmblood - over 95%) [5].

On the other hand, according to the International Embryo Transfer Society (IETS) the higher number of embryo transfers occur in the United States, Argentina and Brazil, in order of importance, countries which together represent over 90% of the activities in this area worldwide. In 2005, 5,700 embryos were transferred in Brazil, none frozen, while across Europe only 711 transfers were done in horses [39].

In this context, it is observed that, although several countries present a prominent role in the worldwide scenario with respect to the use of these reproductive biotechniques, especially embryo transfer, there are few studies about their impact (generation interval, accuracy, selective intensity, inbreeding) on horses breeding programs. Research in this subject would be important to understand the direction that has been given to these tools in different countries and monitor their actual benefit for the horse population.

- Knowledge of interesting traits' economic values

A fundamental requirement for any breeding scheme aiming the improvement of quantitative traits is the establishment of the breeding objectives, involving the relative values of genetic change for all desirable features included in the breeding program. Typically, these values are expressed in monetary terms as weights to be applied to each feature of economic importance [40].

However, few scientific studies have been performed in order to obtain economic weights for traits involved in horse selection programs, were a combination of empirical experience, some biological factors and intuition of designers prevail. There are a few reasons for that.

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[4] Indeed, in exceptional cases may occur insemination as set forth in Article 25 of the Rules of the Association of Breeders and Owners Horse Racing - Stud Book.
"The fecundation of mares can only be made by direct sexual contact, not admitting artificial insemination, but may exceptionally be authorized by the Brazilian Stud Book, by virtue of proven physical impairment of the player, the use of immediate reinforcement with fresh semen collected during the coverage. This procedure, when authorized, will be held only by a veterinarian authorized in advance by the Brazilian Stud Book "

It's often very difficult to determine, in horses, the value of one unit of expression for a given trait in relation to the animal's total value. Economically quantifying units for traits such as speed, dressage, jumping, etc., is far more complex than attributing values to liters of milk, kilos of meat or wool.

The long period of time between mating and expressig the traits of interest in the progeny, besides the difficulties in determining an appropriate function for profitability, provide part of this deficiency. Moreover, according to recent authors, another problem arises from the fact that not always the relative economic weights are linear in a breeding program. Thus, the amount of increase in the genotype for certain character can be strongly dependent on the values of other genetic traits. For example, in horses with outstanding ability to jump, the additional genetic values affecting their training capability is almost neglected, whereas in animals with a low ability to jump, a genotype corresponding to training characteristics can greatly increase its value.

- Diversity of goals within certain breeds

There are equine breeds that are commonly selected by breeder in only one direction, as is the case of the Thoroughbred, where the objective is basically to obtain animals with superior performance in races. In Quarter horses, in addition to races, performance in work tests and conformation may also be targets of breeders since the race is subdivided amongst these strains.

Moreover, in breeds in which animals are involved in a wide variety of uses (work on farms, horseback riding, trekking, exhibitions, equine therapy, equestrian tourism, unskilled riding sports, etc.) breeders seek very different traits, depending on the purpose of raising the animal, hindering the implementation of breeding programs that cover all segments. Brazilian breeds such as the Mangalarga and the Mangalarga Marchador fall into this category.

In these cases, studies involving quantitative and molecular aspects of traits that can meet the desire for the greater proportion of breeders can result in meaningful contributions to selection of reproductive, behavioral, immunological and other traits.

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