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(54) **Title:** METHOD TO PREDICT AN INSEMINATION INTERVAL OF AN ANIMAL AND SYSTEM TO APPLY THIS METHOD

(57) **Abstract:** The present invention pertains to a method to assess the oestrus of multiple animals, for example pigs and cattle, to predict an insemination interval for each animal, comprising for each animal in a first cycle determining a value for at least one characteristic of the oestrus, predicting the insemination interval based on the determination of the said value, inseminating the animal in the said interval, establishing a fertilisation rate of the inseminated animal, and in a second cycle determining a new value for the said at least one characteristic of the oestrus, and predicting a new insemination interval for the said animal using the determination of the new value and the fertilisation rate. The invention also pertains to a system suitable for applying this method.

**Method to predict an insemination interval of an animal and system to apply this method**

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## GENERAL FIELD OF THE INVENTION

The present invention pertains to a method to assess the oestrus of an animal, for example a pig, to predict an optimum insemination interval for this animal. The invention  
10 also pertains to a system for using this method.

## BACKGROUND OF THE INVENTION

15 As is commonly known, for example for pigs (sows and gilts) and cattle (cows and heifers), insemination between 0 and 24 hours before actual ovulation takes place results in the highest fertilisation rate. Outside the optimum interval for insemination the fertilisation rate decreases due to an increase in animals ultimately having a small litter size (in particular for pigs) or no descendants at all. In animal husbandry therefore,  
20 timing of insemination is critical. Usually, this timing is based on the onset of oestrus, as assessed by the farmer. Oestrus in this sense is defined as the period during which the female animal is receptive to mating and ovulates. It is commonly referred to as rut or heat. From one oestrus period to the next there occurs a series of changes, particularly in the ovary, uterus, and vagina, termed the oestrous cycle. With reference to the ovary,  
25 the cycle can be divided into a follicular phase, during which the follicles are ripening, and a luteal phase, during which the corpora lutea develop in the ovulated follicles. During these two phases, mainly oestrogen and progesterone, respectively, are secreted, and these hormones control the uterine and vaginal changes. Since it is known that there is a relationship between the oestrus and ovulation on the  
30 one hand, and features of the animal such as temperature, vulva appearance, hormone levels, state of stress, motion, etc. many methods have been described for the automatic determination of the optimum insemination interval based on this relation. For example, in EP 1 300 119 a device for assessing the oestrus of an animal, in particular a pig, is described, comprising a reaction-detecting means for detecting the standing-  
35 reflex of a pig. The detected reaction is compared with a reaction which is characteristic of a particular stage of the oestrus. This is used to predict an optimum insemination

interval. In EP 2 014 255 an alternative device is described incorporating a complex sensing system to detect all movements of the animal. By analysing these movements during oestrus, an optimum insemination interval is predicted. Indeed, existing methods to predict an optimum insemination interval can be successful, but at the cost of  
5 complexity or heavy operator intervention. When less complex methods are used or operator intervention is reduced, accuracy of the prediction decreases.

#### OBJECT OF THE INVENTION

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There is a need for an improved method and system to predict an optimum insemination interval for animals. In particular in animal husbandry, there is a need for an improved method and system since the economic value of a herd of animals depends largely on the fertilisation rate of the inseminated animals and existing methods are complicated  
15 and/or labour intensive.

#### SUMMARY OF THE INVENTION

20 In order to meet the object of the invention, a method to assess the oestrus of multiple animals, for example pigs, sheep and cattle, is devised, with which method an insemination interval for each animal can be predicted. This method comprises for each of the multiple animals in a first cycle: determining a value for at least one characteristic of the oestrus, predicting the insemination interval based on the determination of the  
25 said value, inseminating the animal in the said interval, and establishing a fertilisation rate of the inseminated animal, and in a second cycle determining a new value for the said at least one characteristic of the oestrus, and predicting a new insemination interval using the determination of the new value and the fertilisation rate.

This invention is based on applicant's recognition that many factors which might be  
30 relevant for the oestrus, and ovulation in particular, are hitherto unknown, or at least their influence on the oestrus is not known. Such factors are for example season, weather, various stress stimuli, diet, age of the animals, parity, breed, genetic line etc. Since the relations hip with oestrus and ovulation is not unambiguously known, existing methods and systems cannot take such factors explicitly into account when predicting  
35 the optimum insemination interval. In the present method use is made of feed-back on the obtained result. By using the obtained fertilisation rate in a first cycle for making a

new prediction in a second cycle, unknown factors can be taken into account without actually knowing the relationship with oestrus in general and ovulation in particular. The specific characteristic of the oestrus used in the present method is not essential to the invention in its broadest sense. It can be as simple as a standing-reflex for pigs as  
5 known from the prior art. Moreover, several ways of predicting the insemination interval based on a measured value can be implemented: for example, one can determine a value and predict the interval based on the height of the value. Alternatively, one can determine when a predetermined value is reached (fulfilling a predetermined threshold), and predict the interval based on that event. In any case, by providing feed-back about  
10 the result achieved, the prediction of the optimum insemination interval will be improved for the second cycle. For example, in the case of pigs one can use the onset of oestrus as a characteristic, based on which one can predict an optimum insemination interval. It is commonly known that at the onset of the oestrus, which onset can be easily established (given the sudden presence of a standing-reflex in the presence of a boar)  
15 by determining a value for the (non-)movement of a pig when applying a displacing means (e.g. as known from EP 1 300 119), it typically takes 24 to 48 hours before ovulation takes place. If one chooses to inseminate about 24 hours ( $\pm \frac{1}{2}$  hour) after onset of oestrus, and it appears that the fertilisation rate is relatively low, in a next cycle, when determining the same value for the (non-)movement of the pig, one may choose  
20 to inseminate about 36 hours ( $\pm \frac{1}{2}$  hour) after the onset of oestrus. It is noted that an optimum insemination interval does not necessarily mean an interval which leads to the highest fertilisation rate. In some circumstances a less than maximum fertilisation rate may economically be optimal. It is also noted that an insemination interval may have any size between for example 1 second and 24 hours, typically depending on the type  
25 of animal, working methods at the farm, or other factors.

The present invention also pertains to a system for assessing the oestrus of multiple animals to predict an insemination interval for each animal, comprising a sensor for determining a value for at least one characteristic of the oestrus of the animal, the  
30 sensor being connected to a central processing unit (CPU) such that the value can be processed by the CPU, the CPU being programmed to predict the insemination interval of the animal using the determined value, the CPU being capable of receiving fertility data of the inseminated animal, and using these data in combination with a determined new value for the at least one characteristic of the oestrus of the animal to predict a new  
35 insemination interval. It is noted that the CPU may be present as a single piece of machinery such as a personal computer. However, it may also be present in a

distributed manner, for example comprising various sub-processors being present in remote locations, which processors communicate via a network, for example the internet. In the latter set-up, at the actual place where the animals are monitored, a very simple processing system may be present, merely capable of receiving data from the sensor and optionally receiving fertilisation data, for example inputted by an operator via a simple keyboard. The actual processing of these data may take place in a remote location, for example a location that is controlled by the provider of the system such that the best care can be taken with regard to adequate processing and service.

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## DEFINITIONS

Fertilisation rate is defined as any rate that corresponds to the fertility of an animal or a herd of animals. The fertility can for example be expressed as the success rate of insemination, for example an integer corresponding to the number of inseminations needed per animal to obtain successful gestation (such that for example the lowest number of inseminations needed, viz. 1, gives the highest integer) or an integer corresponding to the total amount of days needed to obtain successful gestation, etc. The fertility could however also be a rate that corresponds to the average number of descendants (in particular for pigs) after insemination. Each type of animal or way of animal husbandry may define "fertility" in its own practically usable way. The "average number of descendants" may for example be the actual number of live-born descendants in one litter divided by an optimum value for the number of live-born descendants in one litter for the species, expressed as a percentage. For sheep, the typical optimum value for the number of live-born descendants in one litter set to be 2.2. For pigs, in relation to the present description, this value is set to be 14 (but any value can be chosen, depending for example on type of animals, circumstances etc.). This way, for pigs the fertilisation rate after insemination in practice may vary between 0 and 121% for an individual sow. For a herd of sows, the average number of piglets for all inseminated sows is used. This leads to a fertilisation rate which typically varies between 70 and 90%. It is noted that for the fertilisation rate another figure can be used. For example, for some herds, the percentage of inseminated sows being pregnant can be used, whereas for other herds the average number of descendants of the impregnated sows can be used.

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An interval is a time-frame of any length, for example 1-4 hours. The time-frame

however can be as small as for example one or more seconds so that for the practice of insemination the time-frame is equivalent to a particular point in time.

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## EMBODIMENTS OF THE INVENTION

In an embodiment, added to the second cycle are the steps of inseminating the animal in the said new interval, establishing a new fertilisation rate of the inseminated animal, whereafter a third cycle follows comprising the steps of determining a second new value for the said at least one characteristic of the oestrus, and predicting a second new insemination interval using the determination of the second new value and the new fertilisation rate. In this embodiment an even further tuning of the prediction takes place using the newly obtained fertilisation rate. In a further embodiment the formerly obtained fertilisation rate is used together with the new fertilisation rate to provide an even better prediction of the insemination interval.

In a further embodiment, added to the third cycle are the steps of inseminating the animal in the said second new insemination interval, establishing a second new fertilisation rate of the inseminated animal, whereafter  $n$  additional cycles follow,  $n$  being a natural number, each cycle comprising the steps of determining yet another new value for the said at least one characteristic of the oestrus, predicting yet another new insemination interval using the determination of the said another new value and the second new fertilisation rate, inseminating the animal in the said yet another new insemination interval, and establishing yet another new fertilisation rate of the inseminated animal, which yet another new fertilisation rate is to be used in an optional next cycle of the said  $n$  additional cycles. In this embodiment the fine tuning may continue for  $n$  additional cycles, for example until a predetermined mean fertilisation rate is obtained for the herd of multiple animals. Also, this may continue indefinitely to provide for a continuous update of the prediction of an optimum insemination interval. A very significant advantage of this embodiment is the influence of various parameters on oestrus and thus the optimum insemination interval can be monitored easily and reliably. For example, the influence of season follows immediately if the method continuous for more than 1 year, preferably more than 2 years (for verification purposes). Also, the influence of age of the animals can be extracted easily. Once the relationship between such factors and the oestrus and/or optimum insemination interval

is known, it can be taken explicitly into account (for example by using corresponding data in an algorithm) for optimizing the prediction of the insemination interval.

In an embodiment the same algorithm to predict an insemination interval is used for all animals. In this embodiment one and the same algorithm is used for all animals. The  
5 obtained fertilisation data of all of the said multiple animals are used to establish one algorithm that is used to predict an insemination interval for each individual animal upon determining a value for the chosen characteristic of the oestrus. This embodiment provides a relatively simple way to predict the insemination interval but indeed, its  
10 success depends on the homogeneity of the relationship between the characteristic used and actual ovulation within the herd of animals. If the homogeneity is sufficient for obtaining a desired (mean) fertilisation rate, this embodiment can be advantageously used, requiring only modest calculation capacity and thus, may rely on a processing unit as simple as present in a hand-held calculator. However, if the homogeneity within the  
15 herd of animals appears to be too low for obtaining a desired result, one may choose to use an embodiment wherein per animal or group of animals a dedicated algorithm is used to predict an insemination interval for this animal or group of animals. It may simply be that some animals, for whatever reason, show a significantly different relationship between the chosen characteristic of the oestrus and the actual ovulation  
20 then most of the other animals. One could then apply a dedicated algorithm for these animals, either individually or as a group. For example, it is known that young animals may have a significantly different period of time between onset of oestrus and actual ovulation. Also, other characteristics of the oestrus may vary between animals of different age, breed, number of times of farrowing etc. This can be taken into account by  
25 applying a different algorithm for such animals.

In an embodiment, for determining a value for at least one characteristic of the oestrus a sensor is used that is brought in operative connection with each of the said multiple animals by scanning the animals in a consecutive order. It is noted that various methods  
30 for assessing the oestrus of animals are known in the prior art. For example, Ro-Main (Saint-Bernard, Quebec, Canada) sells a system called PIGWATCH®. In this system the heat and ovulation of the sow are assessed by watching standing of a pig. An important disadvantage of this system is that the animal needs to be watched 24 hours a day to make an accurate prediction of the insemination interval. This means that one  
35 sensor is needed per animal that needs to be monitored. This makes the system inherently expensive. The method that is known from EP 1 300 119 also has an

important disadvantage. Since the system requires complex stimulating equipment surrounding the animal, a dedicated fenced device is installed in a stable, and each animal to be monitored is moved from its own accommodation to the fenced device. Such movement may involve either intensive operator support or requires a complex automated animal transporting system. In order to overcome the prior art disadvantages, applicant has devised a method wherein a scanning sensor is used, enabling the sensor to be brought in operative connection with each animal in a consecutive order in a simple manner, not needing intensive operator intervention.

10 In an embodiment the value for the at least one characteristic of the oestrus of the animal is determined at predetermined intervals, of at least 1 hour, preferably at least 2 hours and more preferably between 3 and 8 hours. Applicant recognised that it is not needed to monitor an animal continuously during the oestrus. Since an optimum insemination interval typically last 24 hours, and a working day in animal husbandry typically lasts at least 12 hours, one full assessment each 12 hours would in theory do. However, it was found that many characteristics of the oestrus have only a period of up to about 8 hours wherein they have clear peak values. Therefore, a determination scheme according to this embodiment will suffice for obtaining adequate results, will not needing too many sensor actions which may cause stress in the animal.

20 In an embodiment a value is determined for a characteristic chosen out of the group consisting of standing-reflex, motion, body temperature, in particular skin, rectal or vulva temperature, appearance of the vulva, in particular vulva colour and/or degree of swelling, vulva mucus discharge, vulva mucus turbidity or vulva mucus conductivity. These characteristics of the oestrus are all known to have a relation with the actual ovulation. Moreover, a value for each of these so called standard characteristics can be determined relatively easily by a sensor via a position adjacent an animal, not needing a invasive operation. Therefore, each of these characteristics is ideally suitable in the present invention.

30 In a further embodiment a value of a first characteristic as described here-above is determined each cycle, whereas a value for uterus temperature and/or hormone level, for example estrogen and/or progesterone in blood and/or urine, and/or follicle size is determined in the first cycle only and optionally in one or more following cycles until a prediction of the insemination interval has led to a predetermined fertilisation rate, where-after only a value for the first characteristic is determined in a following cycle.

Applicant recognised that some characteristics of the oestrus have a rather unambiguous relationship with the actual ovulation and thus, with an optimum insemination interval. These characteristics are uterus temperature, hormone level (example estrogen and/or progesterone in blood and/or urine), and follicle size. In many cases however a sensor for determining a value for each of these characteristics needs an invasive operation (uterus temperature and blood hormone level), and/or complex analysing apparatus (hormone level, follicle size) or a skilled operator (follicle size). Applicant however found a further method which does not depend on an invasive operation, but still is suitable for determining a hormone level that can be used to predict ovulation very accurately. Applicant recognised that the luteinising hormone (abbreviated LH hormone), the level of which can be used to very accurately predict the oestrus/ovulation, is also present in saliva of the oral cavity. The level of the LH hormone in the saliva can be measured by simply taking a sample, typically every four hours, and use commonly available techniques to measure the hormone level in the saliva. A very convenient method is to present a tasteful rope or other bite to the animal (for example a bite foreseen with a molasses coating), and after the animal has chewed on the bite for a predetermined amount of time, the saliva present on the bite is automatically analysed using commonly known techniques. This technique is simple, very accurate and does not depend on an invasive operation. The invasive operations, although in theory being ideal for predicting an insemination interval, are not ideally suitable for continuous use in a method and system that meet the objects of the present invention. However, applicant recognised that the characteristics for which an invasive operation is necessary can be very advantageously used to tune the present method to reach a required level of fertilisation rate in a very low number of cycles. When a value for at least one of those additional characteristics is measured at the same time as a value for a standard characteristic, the learning curve will be steeper. Depending on the particular circumstances it may even be that a concurrent determination of the uterus temperature and/or hormone level and/or follicle size, only needs to take place during one cycle before an adequate prediction of the insemination interval can be obtained based on the determination of a value for a standard characteristic only. In other case, it may be that the concurrent determination of a value for an additional characteristic needs to take place during several, in particular consecutive, cycles before an adequate prediction of the insemination interval and thus desired fertilisation rate is obtained.

In an embodiment the animal is inseminated automatically in the predicted insemination interval. The optimum insemination interval may be of short duration. By automatic

insemination (i.e. without operator intervention), a greater chance of successful impregnation is obtained.

As indicated herein before, the present invention also pertains to a system for assessing  
5 the oestrus of multiple animals to predict an insemination interval for each animal. In a further embodiment this system comprises a sensor that can be brought in operative connection with each of the multiple animals in a consecutive order, preferably via a rail system along which the sensor can be moved to provide the operative connection. Ideally, in order to even improve the present method the system further comprises a  
10 simulated male animal that moves along the rail system in conjunction with the sensor. Such a simulated animal may be as simple as merely using the smell and/or sound of a male animal. In other embodiments, an actual fake animal is visually presented to the female animal for example in the form of a picture, film or 3D model.

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#### SPECIFIC EXAMPLES OF THE INVENTION

Figure 1 gives a schematic overview of substantial elements of a system according to  
20 the present invention

Figure 2 shows parts of this system adapted for processing data

Figure 3 shows what results can be achieved when applying the present method

Figure 4 shows other results that can be achieved applying the present method

25

#### **Figure 1**

In figure 1 a schematic overview of substantial elements of a system 20 according to the present invention are shown. The system 20 comprises rails 25 and 26, to which rails a carriage 31 is slidably attached. This way, the carriage 31 can be moved in the direction  
30 A (and vice versa). The system can be used to assess the oestrus of multiple sows 10, which sows are present in housing 1, each sow having a dedicated fenced stable 2, 3, 4, 5 etc.

Attached to the carriage 32 is a sensor 30. In this case it is a sensor to determine a value for the so-called standing-reflex of a sow. As is commonly known, the standing-reflex is  
35 a reaction in response to a stimulus at which the sow hardly moves. Such a stimulus may for example be the application of pressure to a side of the animal. The sensor is

constituted to be able and apply such a pressure on the back of the sow 10. If the sow moves when being in contact with the sensor, a force will be exerted on hinge 32. This force is measured in the present device. When this force is minimal, the value for the standing-reflex is set to 100%. When the force has a certain predetermined maximum value (for example the force just before the hinge starts to actually swing back), the value for the standing-reflex is set to 0%. In the shown embodiment, system 20 comprises a simulated male animal 35 which moves along the rail system in conjunction with sensor 30. In this case, the simulated male animal comprises a display screen in the sow's field of vision. On said screen pictures, preferably motion pictures, of a boar are shown, and at the same time corresponding sound is generated in a sound box (not shown). Alternatively, a 3D simulated boar is used, for example the skippy boar as available from Schippers Bladel BV (Bladel, The Netherlands). This way, the standing-reflex of a sow can be adequately determined. As soon as the oestrus of the first sow is assessed, the carriage is moved along the rail system to a second sow of which the oestrus has to be assessed and the process repeats. This way, with one sensor, each and every sow in the housing can be subjected to an assessment of its oestrus in order to predict an insemination interval. In practice, the sensor will be scanned along the sows such that each sows is subjected to an assessment of its oestrus at a regular interval, typically set at 4 hours. However, any other time may also be chosen. For example, when automatic insemination is not available, a longer interval may be chosen such that the insemination time overlaps with the presence of an operator.

As is commonly known in the prior art, the standing-reflex has a relationship with the ovulation and thus, with an optimum insemination interval. Such a relation is for example known from the prior art patent documents as mentioned before and from *Reprod Dom Anim* **33**, 1998, pp 159-164 (Kemp, Steverink and Soede, Wageningen University, The Netherlands). Thus, based on the determination of a value for the standing-reflex, one can predict an insemination interval. Typically, when detecting the onset of a standing-reflex (which can be defined for example when 70% of the maximum value for the standing reflex is reached), the average optimum insemination interval may lie between 24 and 48 hours after detection of the moment. In the present method, one simply chooses a time for insemination, for example 28 hours after detection of the onset of a standing-reflex, and inseminates the sow at or around this time. Then, the fertilisation rate of this sow is determined. When not impregnated, or not giving rise to life descendants, the fertilisation rate is set to be 0%. When giving birth to X live descendants, the fertilisation rate is set to be  $(X/14) \times 100\%$ . This rate can be

determined for each sow of which the oestrus has been assessed. All of these rates are then inputted in the system (see figure 2), to be taken into account when performing a next cycle for predicting the insemination interval for the sows. An algorithm which can be used for such a second (and following) prediction is also given in conjunction with  
5 figure 2.

It is noted that although the present system is ideally suitable to scan each and every sow in a housing, it may very well be that some sows are not subjected to an assessment of the oestrus simply because the system is informed that these sows  
10 cannot become pregnant anyway, for example since they are already pregnant or since they had an optimum fertility period a short while ago. For this purpose, it is preferred that each animal is provided with an identification means that can be sensed wireless, for example an RFID tag such as the Roxtron tag (available from Roxtron Limited Shenzhen, Guangdong, China) or the SENSOOR tag (available from Agis  
15 Automatisering, Harmelen, The Netherlands). Alternatively, each fenced stable has means for automatic identification of the sow.

It is also noted that although the system has been embodied in conjunction with a determination of a value for a standing-reflex, any other known characteristic for the  
20 oestrus may be chosen (for example any of the characteristics as identified here-above in the paragraph "Embodiments of the invention"). Since the present invention incorporates feed-back about the fertilisation rate obtained, the characteristic chosen is less important for ultimately obtaining good results. However, for convenience sake, determining a value for the standing-reflex is preferred.

25

### **Figure 2**

Figure 2 shows parts of the system as depicted in Figure 1, adapted for processing data. These parts comprise a central processing unit (CPU) 40, which may for example be a  
30 unit as simple as a personal computer. This unit may be present in the animal housing, or at a remote location, for example in an office of the farmer, a vet or the insemination company. The CPU is connected to the sensor 30, for example via a wire, but preferably wireless. This way, the measurement data of the sensor can be inputted in processor of the CPU 40. In this embodiment, the sensor wires the measured data for the force  
35 exerted on hinge 32 (see Figure 1), and the CPU calculates a value for the standing-reflex based on this force.

The CPU is loaded with software code, comprising a dedicated algorithm, to calculate an insemination interval based on the value for the standing-reflex. This algorithm is such that an obtained fertilisation rate can be taken into account as well for calculating an insemination interval. In order to enable this, the CPU 40 is connected to an input device 45 (via a wire, or wireless), in this case a laptop computer present in the housing. Via this laptop computer, the number of live descendants in each litter of each sow is inputted. These numbers are used for example to calculate a mean fertilisation rate by the CPU, which mean rate is used for predicting a next insemination interval for each sow. Various algorithms can be used, a few of which are exemplified here-beneath.

10

In a first algorithm, the system is programmed to detect a threshold value for the standing reflex, for example a value defined as 70% of the maximum standing-reflex. The moment at which this value is determined is called  $t_{\text{threshold}}$ . It is assumed that the insemination interval starts  $X$  hours after  $t_{\text{threshold}}$  and ends 4 hours later.  $X$  is chosen to be less than the average time needed to reach the optimum insemination time, and typically is set to be 28. In this interval the sow will be inseminated. After an appropriate while, the number of live descendants of the sow, following the said insemination is determined. This is done for each inseminated sow. Based on these numbers, the CPU 40 calculates a mean fertilisation rate for the herd of sows, called **Fert-rate<sub>i</sub>** (where  $i = 1$  in the first cycle) expressed as a percentage (100 - 0). In the next cycle ( $i = 2$ ), when for an individual sow the threshold value for the standing-reflex is determined, a new prediction of the insemination interval is being made. The new interval starts at  $t_{\text{threshold}} + X + (100 - \text{Fert-rate}_i)/Y$  hours and ends 4 hours later. Typically  $Y$  is set to be 10. The sow is inseminated in this interval. These steps are performed for each sow. In the end, the number of live descendants of each sow are determined and inputted in CPU 40.

The numbers are used to calculate a new average fertilisation rate (called **Fert-rate<sub>i</sub>**,  $i = 2$ ). This rate is additionally used for predicting a new insemination interval ( $t_{1,2}$ ). As long as the average fertilisation rate increases,  $(100 - \text{Fert-rate}_{i-1})/Y$  hours are added to the beginning and end time of the insemination interval. When the fertilisation rate, going from cycle  $n$  to cycle  $n+1$  decreases (such that the optimum interval has been passed),  $(100 - \text{Fert-rate}_{i-1})/Y$  hours are deducted instead of added. This remains so as long as the fertilisation rate keeps increasing again. Thereafter the new amount of hours is added again. This leads to a more or less oscillating pattern. The algorithm can be expressed in mathematical formula 1:

35

$$t_{1,2} = t_{threshold} + X + \sum_{i=2}^n \frac{\pm (100 - Fert-rate_{i-1})}{Y}, t_{threshold} + (X + 4) + \sum_{i=2}^n \frac{\pm (100 - Fert-rate_{i-1})}{Y} \quad (1)$$

5 It is noted that the length of the interval (4 hours in equation 1) may be chosen to have any length, for example only 2 or even 1 hour. A shorter interval may increase the accuracy of the prediction of an insemination interval leading to higher fertilisation rates. Also, the length of the interval can be made a variable number in the equation, and optimised according to the results achieved. The values for **X** and **Y** may also be given  
 10 other values depending i.a. on the circumstances (summer/winter; diet, etc) and/or parameters of the sows (age, breed, relationship between standing-reflex and individual fertilisation rate, etc). They may be the same for the herd as a whole or one or more of these parameters may differ per group of sows or even per individual sow.

15 In another embodiment, it is not a moment in time when a threshold value is reached that is detected, but an actual value for the standing-reflex (again in a range of 100 to 0). In this embodiment, when a standing-reflex is determined having a value that is within a predetermined range of 100 to 70, which value is called **V<sub>charac</sub>**, the insemination time **t<sub>insem</sub>** (i.e. an interval having a length of 1 hour, starting at **t<sub>insem</sub>**) is  
 20 calculated by adding  $(100 - V_{charac}) \times (X/M)$  hours to the time (**t<sub>m</sub>**) at which it was determined that the standing-reflex had a value within the interval 100 to 70. In this calculation **X** has the same meaning as above, thus typically set at a value of 28, and **M** has a value of 30. In effect, when **V<sub>charac</sub>** in the first cycle is determined to have a value of 100, insemination has to take place at **t<sub>m</sub>** or within one hour from **t<sub>m</sub>**. When **V<sub>charac</sub>** has  
 25 a value of for example 80%, **t<sub>insem</sub>** is equal to  $t_m + (100 - 80) \times (28/30) = t_m + 19$  hours. This means that insemination has to take place in an interval starting at **t<sub>m</sub> + 19** hours en ending at **t<sub>m</sub> + 20** hours. After impregnation the mean fertilisation rate is determined for the herd of inseminated sows (**Fert-rate<sub>i</sub>**, **i = 1**). This value is used in the next cycle (**i = 2**) to calculate a new insemination interval for an individual sow when a standing-  
 30 reflex is determined for this sow having a value that is within a predetermined range of 100 to 70. Then, to the value for **X** an additional number of hours is added equal to  $(100 - Fert-rate_i)/Y$  (wherein **Y** has the same meaning as above). The sow is inseminated in this interval. These steps are performed for each sow. In the end, the number of live descendants of each sow are determined and inputted in CPU 40. The numbers are  
 35 used to calculate a new average fertilisation rate (called **Fert-rate<sub>i</sub>**, **i = 2**). This rate is

additionally used for predicting a new insemination interval. Again, as with formula 1, as soon as the fertilisation rate starts to decrease after a new insemination, hours according to the formula should be deducted from **X** etc. This algorithm can be expressed in mathematical formula 2 (wherein  $t_{insem}$  represents an interval having a length of 1 hour, starting at  $t_{insem}$  and ending at  $t_{insem} + 1$ hour):

$$t_{insem} = t_m + (100 - V_{charac}) \times \frac{X + \sum_{i=2}^n \pm \frac{100 - Fertrati - 1}{Y}}{M} \tag{2}$$

10

It is noted that the values for **X**, **Y** and **M** may be given other values depending i.a. on the circumstances (summer/winter; diet, etc) and/or parameters of the sows (age, breed, relationship between standing-reflex and individual fertilisation rate, etc). They may be the same for the herd as a whole or one or more of these parameters may differ per group of sows or even per individual sow.

It is also noted that in the shown embodiments, the mean fertilisation rate for the herd of sows which are subjected to assessment of the oestrus is being used. In an alternative embodiment, the individual fertilisation rate for each sow is used to have a dedicated calculation of the insemination interval for each sow,

**Figure 3**

Figure 3 gives an example of results that can be achieved when applying the present method. What is shown is the increase in mean fertilisation rate when applying a method as described in conjunction with Figures 1 and 2, in particular when using an algorithm in accordance with formula 1, using the same values for **X** and **Y** for each sow (set to the typical values of 28 and 10 respectively), and also using a mean value (for the herd of sows) for the fertilisation rate in each cycle. What can be seen is that the fertilisation rate steadily increases from an initial 65% in the first cycle to around 100% in the fourth cycle. Thereafter there is some oscillation in the fertilisation rate around the value of 100%.

**Figure 4**

Figure 4 gives another example of results that can be achieved when applying the present method. In this case the same method as used for obtaining the results as shown in figure 3 is used, but in addition to the determination of a threshold value for the standing-reflex the follicle size is also measured in the first cycle by using an art-known echo-doppler apparatus such as the ProSound™ C3CV ultrasound system with a UST-9112-5 endovaginal transducer (all available from Aloka, Tokyo, Japan). In this embodiment, use is made of the art-known knowledge that follicle size has a very straightforward relationship with ovulation time. This means, the values of **X** and **Y** can be estimated quite precisely based on a value for the follicle size. For example, based on a certain follicle size, the number of hours until ovulation and the variation in this number can be predicted quite precisely, which will give rise to good estimates for **X** and **Y**. The effect of this is that the obtained fertilisation rate increases more rapidly in consecutive cycles. In the shown case a value of around 100% is reached in cycle 3, one cycle earlier than in case the method corresponding to Figure 3 is used. This may look not too impressive but for every day economics in pig husbandry this can be very important since a sow is typically used for breeding only about 6-7 cycles. Thus, if the desired fertilisation rate is obtained one cycle earlier, this may correspond to a significant revenue increase per sow. Also, the oscillation is less in this example which may improve the average number of live descendants over time.

It is noted that instead of follicle size, also another characteristic can be measured (maybe even in addition to the follicle size) of which it is known that there is a very clear relationship with the ovulation time. Such a characteristic may be for example uterus temperature and/or hormone level, in particular estrogen and/or progesterone in blood and/or urine.

**CLAIMS**

1. Method to assess the oestrus of multiple animals to predict an insemination interval for each animal, comprising for each animal:

5

in a first cycle:

- determining a value for at least one characteristic of the oestrus,
- predicting the insemination interval based on the determination of the said value,
- 10 - inseminating the animal in the said interval,
- establishing a fertilisation rate of the inseminated animal,

in a second cycle:

- 15 - determining a new value for the said at least one characteristic of the oestrus, and
- predicting a new insemination interval for the said animal using the determination of the new value and the fertilisation rate.

20 2. A method according to claim 1, characterised in that added to the second cycle are the steps of:

- inseminating the animal in the said new interval,
- establishing a new fertilisation rate of the inseminated animal,

25

whereafter a third cycle follows comprising the steps of:

- determining a second new value for the said at least one characteristic of the oestrus,
- and
- 30 - predicting a second new insemination interval using the determination of the second new value and the new fertilisation rate.

35 3. A method according to claim 2, characterised in that added to the third cycle are the steps of:

- inseminating the animal in the said second new insemination interval,
- establishing a second new fertilisation rate of the inseminated animal,

whereafter n additional cycles follow, n being a natural number, each cycle comprising  
5 the steps of:

- determining yet another new value for the said at least one characteristic of the oestrus,
- predicting yet another new insemination interval using the determination of the said  
10 another new value and the second new fertilisation rate,
- inseminating the animal in the said yet another new insemination interval, and
- establishing yet another new fertilisation rate of the inseminated animal, which yet another new fertilisation rate is to be used in an optional next cycle of the said n additional cycles.

15

4. A method according to any of the preceding claims, characterised in that the same algorithm to predict an insemination interval is used for all animals.

5. A method according to any of the claims 1 to 3, characterised in that per animal or  
20 group of animals a dedicated algorithm is used to predict an insemination interval for this animal or group of animals

6. A method according to any of the preceding claims, characterised in that for  
25 determining a value for at least one characteristic of the oestrus a sensor is used that is brought in operative connection with each of the said multiple animals by scanning the animals in a consecutive order.

7. A method according to any of the claim 1-6, characterised in that the value for the at  
30 least one characteristic of the oestrus of the animal is determined at predetermined intervals, of at least 1 hour, preferably at least 2 hours and more preferably between 3 and 8 hours.

8. A method according to any of the preceding claims, characterised in that a value is  
35 determined for a characteristic chosen out of the group consisting of standing-reflex, motion, body temperature, in particular skin, rectal or vulva temperature, appearance of the vulva, in particular vulva colour and/or degree of swelling, vulva mucus discharge,

vulva mucus turbidity or vulva mucus conductivity.

9. A method according to claim 8, characterised in that a value of a first characteristic is determined each cycle, whereas a value for uterus temperature and/or hormone level, in particular estrogen and/or progesterone in blood and/or urine, and/or follicle size is determined in the first cycle only and optionally in one or more following cycles until a prediction of the insemination interval has led to a predetermined fertilisation rate, where-after only a value for the first characteristic is determined in a following cycle.
10. A method according to any of the preceding claims, characterised in that the animal is inseminated automatically in the predicted insemination interval.
11. A system for assessing the oestrus of multiple animals to predict an insemination interval for each animal, comprising a sensor for determining a value for at least one characteristic of the oestrus of the animal, the sensor being connected to a central processing unit (CPU) such that the value can be processed by the CPU, the CPU being programmed to predict the insemination interval of the animal using the determined value, the CPU being capable of receiving fertility data of the inseminated animal, and using these data in combination with a determined new value for the at least one characteristic of the oestrus of the animal to predict a new insemination interval.
12. A system according to claim 11, characterised in that the system comprises a sensor that can be brought in operative connection with each of the multiple animals in a consecutive order.
13. A system according to claim 12, characterised in that it comprises a rail system along which the sensor can be moved to provide the operative connection.
14. A system according to claim 13, characterised in that it further comprises a simulated male animal that moves along the rail system in conjunction with the sensor.

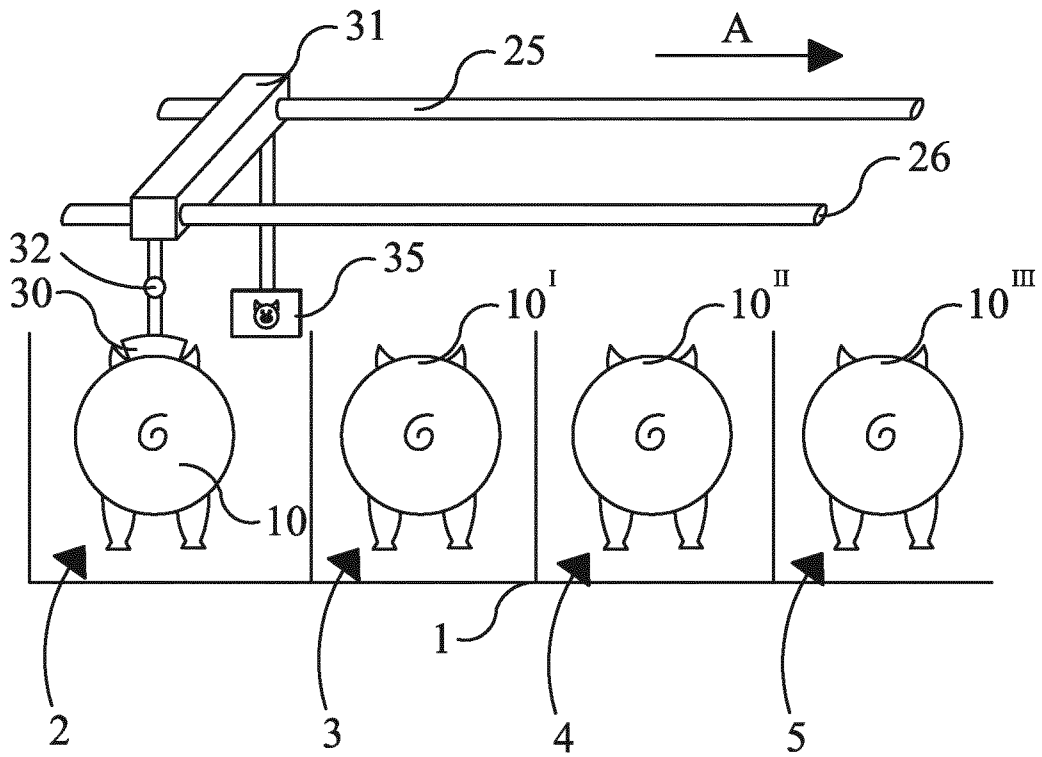


FIG. 1

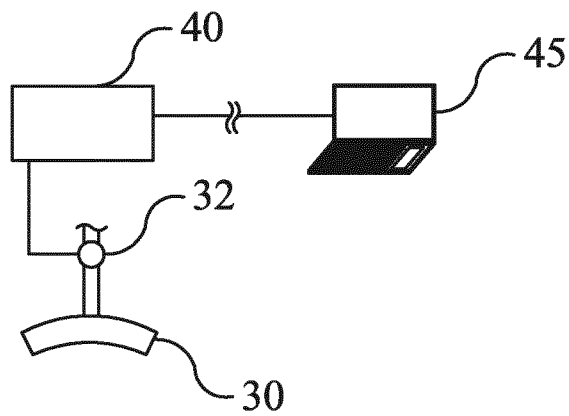


FIG. 2

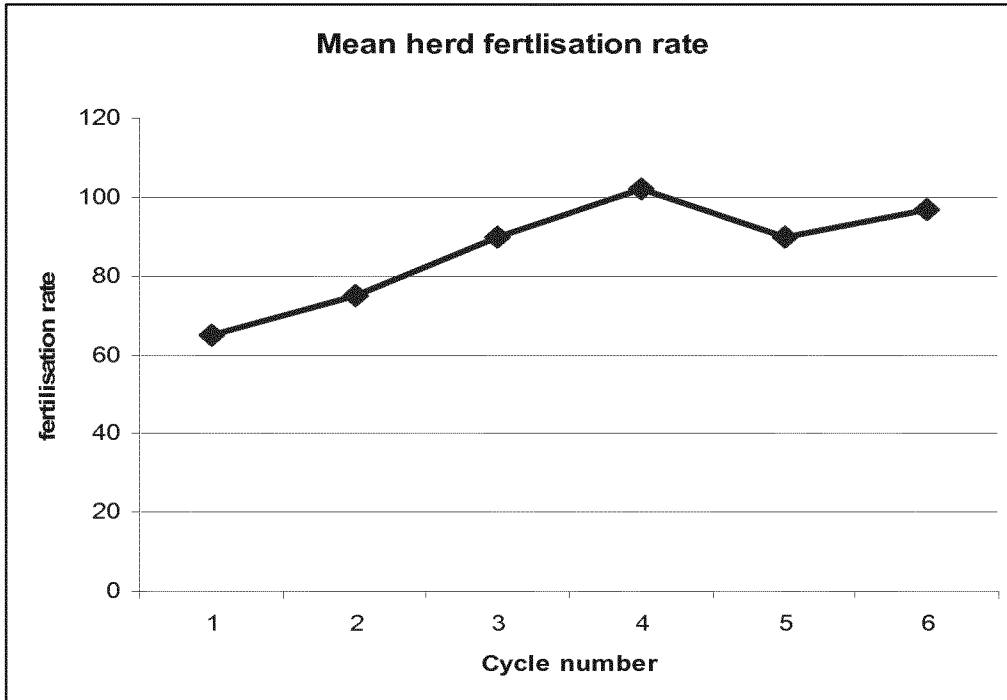


FIGURE 3

5

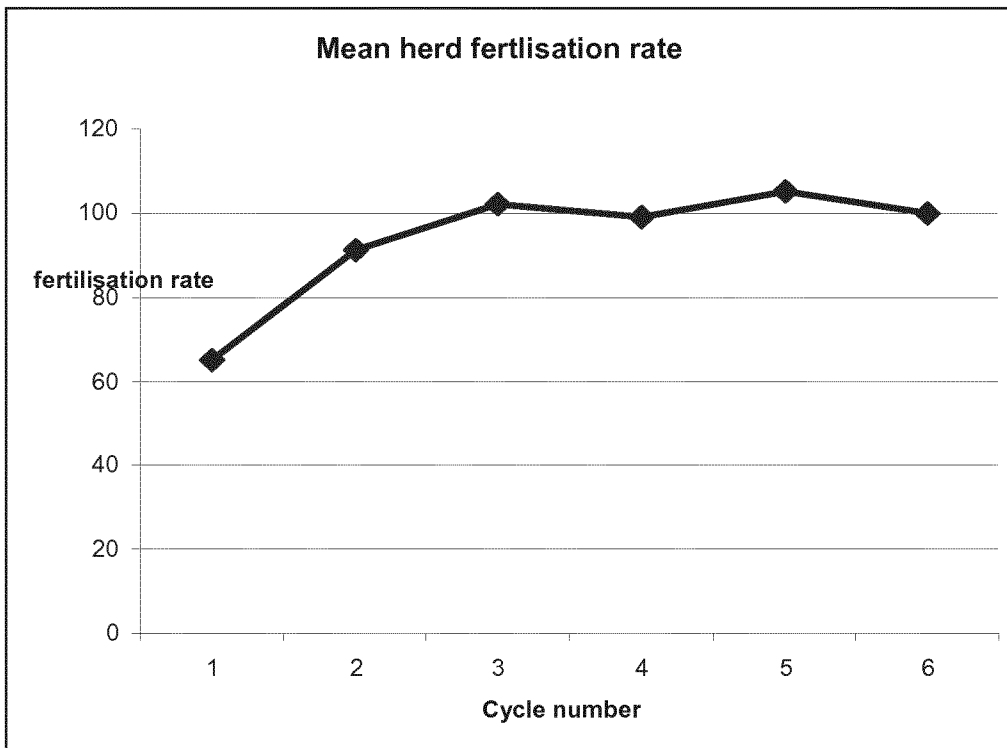


FIGURE 4

INTERNATIONAL SEARCH REPORT

International application No  
PCT/EP2012/057478

A. CLASSIFICATION OF SUBJECT MATTER  
INV. A61B10/00 A61D17/00  
ADD.  
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED  
Minimum documentation searched (classification system followed by classification symbols)  
A61B A61D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)  
EPO-Internal, BIOSIS, EMBASE, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Y	Paragraphs 24-27; claims 10-21; figures 1-3	14
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Y	Figures 1-3; claims	14
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Y	Figure 7; page 4, lines 26-31; page 17, line 15-Page 19, line 16; page 29, line 15-page 30, line 2	14
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Further documents are listed in the continuation of Box C.

See patent family annex.

\* Special categories of cited documents :

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Date of the actual completion of the international search  5 July 2012	Date of mailing of the international search report  02/08/2012
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Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer  Vanmontfort, D
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International application No  
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A	abstract; claims; figure 1 -----	1-13
Y	EP 1 300 119 A2 (LELY ENTPR AG [CH]) 9 April 2003 (2003-04-09) cited in the application	14
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