Designing a stretcher artificial insemination, collection and transfer of embryos goats

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Abstract. The purpose of this work is to build a stretcher for artificial insemination, collection and transfer of embryos in goats taking into account the losses that have been identified in the population of these animals, where the female is injured in the process of attachment, generating losses of time by the operator trying to control the animal and this in turn leads to costs for the breeding laboratory. This is why, with the development of this work, the construction of a stretcher with pneumatic lift that mitigates the existing problem in goat production, which will allow the veterinarian to perform the process properly, achieving a practical adjustment in the height during the intervention.

Introduction
Currently there aren’t studies or data on any type of development of stretchers for artificial insemination in goats or any type of design implemented to improve the conditions of subjection of this process, but if they have found works and scientific articles of other Universities and companies on the subject of artificial insemination, where they make reference to the importance of using a stretcher with the specific conditions for this process [1].

In the Universidad de la Salle in Bogotá, Colombia, the program of veterinary medicine belonging to the faculty of agricultural sciences in one of its works on artificial insemination emphasized the importance of the stretcher; for this process the female was placed on the inclined plane of a horizontal stretcher in such a way that the head was tilted down, ensuring that internal organs move down, and not intervene in surgery. Having this instrument is very important since to have the proper inclination so that the organs move and you can operate correctly. The embrocation of the operative field was performed, using alcohol and iodine interspersed 8 times ending in alcohol [2]. In addition, a medial laparotomy of 5 to 7 cm was performed, and 3 cm in front of the udder. Afterwards, the oviduct of the female sheep was exposed and, helped by a catheter, 18 embryos were introduced in the right oviduct and 24 embryos in the left oviduct of each female, for a total of 168 embryos used in the project, which were left for a period of time seven days of development. The stretcher was of great help during the operation procedure maintaining a stable position of the animal and obtaining good results [2].

In another scientific article carried out at the Instituto Nacional de Tecnología Agropecuaria in Bariloche, Argentina, it is specified that the embryo collection methodology is carried out with the help of a stretcher, used to obtain embryos, and consists of injecting a liquid medium to the sheep with a position of 45º, to produce a current of drag (washing or flushing) through the uterine horns. These interventions are carried out under general anesthesia. The medium used is phosphate buffer solution

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(PBS), enriched with 4% bovine serum albumin fraction V (BSA) or 10% fetal bovine, ovine or caprine serum. The serum is centrifuged at 2000 grams for 15 minutes. The supernatant is taken and a second centrifugation is performed. It is filtered through a 0.22 μm membrane and subjected to the action of gamma rays (IETS). The inactivation of the complement protein is carried out at 56 °C for 30 minutes. The inactivated filtered serum can be stored for one year at a temperature of -20 °C [3].

In the evaluation of the effect of repeated treatment with FSH+eCG in the Ovarian response and laparoscopic follicular aspiration in prepubertal calves carried out at the Universidad Austral de Chile, the animals were placed on a stretcher in which they entered the surgery pavilion. They were shaved, washed and disinfected in the mid-ventral region with 70% alcohol and iodine solution. The calf was completely covered with a sterile field cloth and the intervention was carried out in a pavilion previously subjected to ultra violet light. It was provided with all the basic comforts: surgical light equipment, cloths, aprons and sterile materials.

The holding table, with the calf in the dorsal decubitus position, was adjusted in such a way that the animals remained in a head-down position forming an angle with the floor of approximately 45° in order to displace the viscera cranially [4]. Embryo transfer is a method of artificial reproduction that has begun to be used in our country. This article refers to the method of embryo transfer that has begun to be used in our country by Dr. Artur Fischer, which consists in the obtaining of several embryos that were generated by a donor female and that, subsequently, will be inoculated (or transferred) in recipient females (pregnant).

**Materials and method**

To carry out this project, an investigation of descriptive depth was applied because it will be possible to obtain the required information through an exact description of the activities and processes to carry out the necessary designs, specifying the important and relevant properties for the construction of the stretcher.

This research has a mixed (qualitative-quantitative) approach because it is based on a series of calculations and measurements to achieve the corresponding design. The design of this research was classified as applied research, since all the knowledge acquired during the professional training stage related to the design was used [5,6]. We identified the classes of kinematic pairs that are part of our mechanism, for the first sliding-guide union we have: S=6-H=6-1=5. A kinematic pair of class V, each of the links of this pair has only one possible simple movement: displacement along the x-axis (Figure 1(a)). Therefore, the number of degrees of freedom is H=1. In this way, this pair must be classified as V class. This board is called slider, prismatic or slider.

For the second piston-slide connection we have: S=6-H=6-2=4. A kinematic pair of class IV, the piston has a rotational movement with respect to the slide, and the slide still has only a simple movement possible: displacement along the x-axis. Therefore, the number of degrees of freedom of this mobile joint is H=2. This pair is also called a pair or cylindrical joint (Figure 1(b)). The mechanism that was selected, has a pneumatic system composed of a double-acting cylinder and its respective actuation valve. This system was chosen due to the advantages that the use of pneumatics offers over other systems for the development of this project; low cost of its components, its ease of design and implementation and the low torque or weak force that can develop at low pressures with which it works (typical 6 bar) which constitutes a safety factor. Other favorable characteristics are the zero risk of explosion, its easy conversion to the rotary movement, as well as the linear, the possibility of transmitting energy over long distances, easy construction and maintenance and economy in applications [8].

The average weight of the goats at the “Universidad Francisco de Paula Santander Seccional Ocaña, Colombia”, differ according to race, there are the Santandereana criollas weighing between 30 to 40 kg which are the races that have less weight and the French Alpines that weigh between 40 kg to 50 kg, being the heaviest. These weights are taken once they have reached adulthood. Taking into account this information, we have that the maximum weight that will support the stretcher is 50 kg. To determine the size ranges were taken from the smallest goats to the largest ones in which the following data were obtained: Body length: 65 cm to 123 cm and height: 65 cm to 75 cm.
The double effect cylinders do not have a spring to return to their equilibrium position, so their force does not decrease in the forward stroke, but in their recoil stroke, due to the decrease in the piston area due to the existence of the piston rod. [8], for this reason this type of actuator was selected because the cylinder is required to lift and hold the load in a certain position and return it to its initial position when the valve is operated again. To determine the diameter of the cylinder, the equation of the advancing force was taken into account, in order to select the pneumatic cylinder capable of lifting the maximum weight at which the structure will be subjected. It was calculated with a force of 500 N which is the maximum that will support the stretcher in terms of mass by acceleration, this force was taken from the reproduction laboratory of the heavier goats, initially a pressure of 100 psi was chosen, which is the most common in a commercial compressor. Thus, the following initial values are available for the selection of the pneumatic actuator as $P_{\text{air}}=6.98$ bar. Subsequently, to calculate the forward force Equation (1) was used:

$$F_{\text{Forward}} = P_{\text{air}} \times \frac{\pi D^2}{40}$$
\[ F_{\text{Forward}} = 6.89\text{bar} \times \frac{\pi \times D^2}{40} \rightarrow D = \pm 3.37 \text{ mm} \]

It was found that for the pneumatic actuator to lift the maximum weight of a goat of 50 kg, the diameter of the actuator must be greater than $D=30.37$ mm, therefore, a commercial pneumatic actuator was selected on the market with a diameter of $D=40$ mm. For the selection of the diameter of the rod that is part of the cylinder, the following aspects were taken into account: Cylinder load force: This force depends on the assembly forms of the cylinder which are basically 3 groups, of which group 2 was chosen; being this one that applies to our assembly. Group 2: The assembly absorbs the force of the cylinder in the centerline and allows movement in a plane. It is used when the machine where they are mounted moves following a curved line [8]. Depending on the type of assembly selected and the type of connection, the buckling factor equal to 2, once the stem buckling factor and the current stroke have been established, the basic length is calculated using the following Equation (2):

$$\text{Basic length} = \text{Current career} \times \text{Buckling factor}$$

Subsequently, the thrust force was calculated using the following Equation (3):
After having carried out the previous analysis, for safety a commercial pneumatic actuator with a stem diameter (d=16 mm) was chosen, thus guaranteeing that the stem does not suffer buckling. Likewise, a commercial double-acting actuator was chosen with the following specifications: Movement Pattern: double effect, cylinder diameter: 40 mm, stem diameter: 16 mm, stroke: 170 mm, working fluid: air, pressure range: 14 Psi-150 Psi and damping: adjustable. On the other hand, the forward and backward force, and the air consumption required to drive the selected pneumatic actuator were calculated considering Equation (3) and Equation (4):

\[
F_{\text{Forward}} = P_{\text{air}} \times \frac{\pi \times 40 \text{mm}^2}{40} = 866.45 \text{ N}
\]

\[
F_{\text{Backward}} = P_{\text{air}} \times \frac{\pi (D - d)^2}{40}
\]

\[
F_{\text{Backward}} = 6.89 \text{bar} \times \frac{\pi (40 \text{mm} - 16 \text{mm})^2}{40} = 311.92 \text{ N}
\]

Once the forces are calculated, it is necessary to take into account the friction of the piston to have a higher reliability factor of the system. The friction of the piston is equivalent to a value between 3% and 10% of the calculated force [9]. The maximum value of the forward and backward forces was 866.45N and 311.92N respectively.

For the air consumption of the cylinder, a function of the compression ratio, the piston area and the stroke [9] taken into account, Equation (5):

\[
\text{Air consumption} = \text{Compression ratio} \times \text{Piston area} \times \text{Race} \times \frac{\text{Cicles}}{\text{Minutes}}
\]

The compression ratio referred to sea level is given by the following Equation (6):

\[
\frac{0.98 + P_{\text{air}} \text{(bar)}}{0.98}
\]

Being: Q=total air in (dm³/min), D=cylinder diameter [mm], l=stroke in [mm] and n=cycles per minute. For the case of the double-effect cylinder, neglecting the volume of the shank, we have that the consumption of air in liters per minute for the system implemented is governed by the following Equation (7):

\[
Q = 2 \times \frac{0.98 + P_{\text{air}} \text{(bar)}}{0.98} \times \frac{\pi \times D^2 \times l}{4000000} \times n
\]

\[
Q = 2 \times \frac{0.98 + 6.89 \text{(bar)}}{0.98} \times \frac{\pi \times 40 \text{mm}^2 \times 170 \text{mm}}{4000000} \times 1 = 3.41 \text{ dm}^3 \text{ min}
\]

To determine the maximum load that the selected pneumatic cylinder is capable of lifting, the following calculations were made: It was determined that, at its maximum pressure, the cylinder is capable of lifting a weight of 132.45 kg, taking into account the following Equation (8) to Equation (10):

\[
P_{\text{air-max}} = 150 \text{psi} \times \frac{1 \text{ bar}}{14.50 \text{ psi}} = 10.34 \text{ bar}
\]
To determine the minimum amount of pressure required to lift a 50 kg weight, the following calculations were made, based on Equation (11) to Equation (13):

\[
F_{\text{Max}} = \frac{P_{\text{air}} \times \pi D^2}{40} = 10.34 \text{bar} \times \frac{\pi \times 40 \text{mm}^2}{40} = 1299.36 \text{ N}
\]

\[
m_{\text{Max}} = \frac{1299.36 \text{ N}}{9.81 \frac{\text{m}}{\text{s}^2}} = 132.45 \text{ kg}
\]

\[
F_{\text{Forward}} = 50 \text{ kg} \times 10 \frac{\text{m}}{\text{s}^2} = 500 \text{ N}
\]

\[
F_{\text{Forward}} = \frac{P_{\text{air}} \times \pi D^2}{40} = 500 \text{ N} \quad \rightarrow \quad 500 \text{ N} = \frac{P_{\text{air}} \times \pi \times (40 \text{mm})^2}{40}
\]

\[
P_{\text{air-minima}} = \frac{3.97 \text{ bar} \times 14.50 \text{ psi}}{1 \text{ bar}} = 57.70 \text{ psi}
\]

The result obtained is the minimum pressure to be exerted on the cylinder to lift the maximum weight of goats with which the reproduction laboratory of the Universidad Francisco de Paula Santander Ocaña. This pressure can be taken as a reference point to choose with more accuracy the air compressor with which the pneumatic system will be operated.

**Results and discussion**

Taking into account the specifications given by the veterinarian in terms of the size of the goats and the function that will meet, a stretcher was designed with the necessary characteristics for the correct support of the animal, with a mechanism that allows different levels of height to be practical and easy way for the operator. Detailed engineering was applied in order to fully appreciate each of the measurements and parts of the stretcher, as can be seen below in Figure 2.

**Figure 2.** Design of the base of the structure of the stretcher. Measurements in mm.

A grab handle was designed that functions as an adjustable extension of the stretcher. This stretcher was designed with the specifications given by the veterinarian of the goats that were currently in the university, but in order to make our design, a future functional design was chosen to design this extension according to the size of larger goats found in the market, as shown in the following Figure 3.

Subsequently, this piece was designed taking into account the measurements obtained from the goats with which the university has, and this is where the animal is located to be subjected to the insemination process. The handles were located at an average distance so that the adjustment was appropriate for both a large goat and a smaller one, as shown in the following Figure 4:
The static analysis of the stretcher using SolidWorks Simulation 2017 to validate the proposed design and check the selection of the material, which was initially chosen for its characteristics and for being a material with an excellent quality-price ratio compared to most steel alloys for the same purpose. The selected material was AISI 1020 (commercial steel). The maximum force to which the structure of the stretcher is subjected is 500 N. Figure 5 and Table 1 show structure design and the properties of the material selected, the failure criterion used for the structural analysis is specified using a solid mesh, with 4 covered points with a total number of nodes of 21430 and 9613 elements.

| Table 1. Material properties. | AISI 1020 |
|------------------------------|-----------|
| First name                   | AISI 1020 |
| Type of model                | Isotropic linear elastic |
| Default error criteria       | Maximum stress of von Mises |
| Elastic limit                | $3.51 \times 10^{8}$ N/m² |
| Traction limit               | $4.20 \times 10^{8}$ N/m² |
| Elastic module               | $2.05 \times 10^{11}$ N/m² |
| Poisson's coefficient        | 0.29 |
| Density                      | 7900 kg/m³ |
| Cutting module               | $7.70 \times 10^{10}$ N/m² |
| Thermic dilatation coefficient | $1.50 \times 10^{-6}$ 1/°K |

First, meshing was performed; meshing is a crucial step in design analysis. The automatic mesh in the software generates a mesh based on a global element size, a tolerance and local mesh control specifications. The mesh control allows you to specify different sizes of component elements, faces, edges and vertices [10], was applied in order to analyze a model as real as possible and ensure that it meets the objective of supporting external loading. Secondly, the tension structure was analyzed, the
SolidWorks software has as its main criterion of failure the stress of Von Mises. This maximum stress criterion is based on the von Mises-Hencky theory, also known as shear energy theory or distortion energy theory. In structural engineering it is used in the context of fault theories as an indicator of a good design for ductile materials [10-12].

As an optimal design criterion, the piece must not exceed the elastic limit of the construction material, which in this case is 351.60 MPa, obtaining values of minimum voltage: 0.009189 MPa, node: 19849 and maximum voltage: 41.47 MPa, node: 18738 (Figure 6(a)). The previous values are the result of the static study carried out. The theory states that a ductile material begins to yield in a location when the Von Mises tension is equal to the elastic limit, as it is evident that there is no failure because the tension and the elastic limit they do not reach to equal.

Thirdly, the resulting displacements were determined and a maximum displacement of 0.73 mm was obtained, it is a very small value in comparison to the force that it will support, it also indicates at which point it could have a greater probability of failure (Figure 6(b)).

Fourth, this analysis showed an equivalent unit strain in the structure, as shown in Figure 6(c), unitary deformation is related to the change in the size or shape of a body due to internal stresses produced by one or more forces applied to it or the occurrence of thermal expansion [13]. From the study, the following information was obtained, minimum deformation 1.6x10^{-012} mm, node: 8841 and maximum deformation. 0.000192769 mm, node: 493. These minimum deformations obtained can be considered negligible.

![Figure 6. (a) Elastic limit of the structure. (b) Displacement of the structure and (c) Equivalent unit deformation.](image)

**Conclusions**

Through simulations performed on the most critical elements of the design, it was determined that the selected materials and geometry guarantee a correct operation of the stretcher, due to the fact that tensions, deformations and displacement were obtained well below the material limits, presenting a degree of reliability optimal for the construction of the stretcher. Establishing that the material selected AISI 1020 steel is a material that meets the design conditions and that the structure of the stretcher will support the load to which it will be subjected.

The use of a pneumatic actuator in the lifting mechanism allows a greater range of heights to be obtained, guaranteeing the veterinarian a practical and comfortable process when using the stretcher.

The pressure indicated in the table of operation properties of the pneumatic cylinder must not be exceeded. The stretcher can work with a minimum pressure of 57.70 psi, but it is recommended to look for a compressor above this pressure. Once the goat is located, it is recommended to verify that the upper and lower extremities are well restrained, to ensure that they are immobile at the moment of carrying out said process.
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