FEED-A-GENE

Adapting the feed, the animal and the feeding techniques to improve the efficiency and sustainability of monogastric livestock production systems

Deliverable D2.2

A feeding device allowing individual feed intake recording in group-housed rabbits

Due date of deliverable: M30

Actual submission date: M31

Start date of the project: March 1st, 2015 **Duration:** 60 months

Organisation name of lead contractor: IRTA

Revision: V1

Dissemination level	
Public - PU	**X**
Confidential, only for members of the consortium (including Commission Services) - CO	
Classified, as referred to in Commission Decision 2001/844/EC - CI	

Table of contents

1. Summary

Objectives:

The objective of this document is to provide a description of the feeding device (feeding device) for the control of individual feed intake of rabbits raised in collective cages. This description aims to provide details on all the components involved in the feeding device as well as to show how the developed software computes individual feed intake of rabbits raised in groups.

Rationale:

Given the relative low genetic correlation between feed efficiency measurements and growth performance in rabbits, it is highly desirable to have direct measurements of feed intake to more effectively genetically act on the feed efficiency. In this context, recording feed intake in animals raised in groups would be highly valuable since these are the conditions in which the animals perform in commercial farms. Until now, individual feed intake in rabbits has been measured by housing the animals individually. This procedure ignores the unperfected genetic correlation that might exist between performance of rabbits housed in a group and those housed in individual cages. With a device like the one we have developed, it is possible not only to assess this correlation, but also to provide selection methods using the individual information generated in the selection nucleus and experimental farms.

Although our initial aim was to develop a device to be used for selection processes, other research activities requiring individual control of feed intake in group-housed rabbits, like for example in nutrition, could take advance of the device we have designed and manufactured.

Teams involved:

Feed-a-Gene partners involved:

IRTA

Claitec

INRA – as coordinator of the task in which this activity is conducted

The developments achieved in relation to the design and manufacturing of the 30 feeder units have been realized through cofounding by the Feed-a-Gene project and the Spanish national project “***Mejora de la eficiencia alimentaria en el crecimiento y la reproducción en especies prolíficas. Determinismo genético de sus componentes y estrategias de selección (GENEF)” RTA2014-00015-C02***

Species and production systems considered:

Rabbits raised in collective cages. The initial subsector to which the feeding device could be of interest is research centres in addition to selection nucleus aiming to improve the efficiency of their lines. Nowadays this type of facilities can be found in France, Spain, Italy, Hungary, and different countries of Northern Africa.

Reports for the non-favourable informed points of the check list

1) The dissemination level indicated in the DoA was Public. However given that our aim is to apply for an intellectual property protection (e.g., though a patent), we need to keep all the information concerning this feeding device as confidential, otherwise we could not apply for this patent application. We have not yet applied for a patent application due to a lack of funds to do so. In the next months, we do expect either to file an application or discard this possibility so that, in the latter case, the deliverable could be made public.

2. Introduction

In this report, all the features of a feeding device for individually recording feed intake of group-housed rabbits are described. This activity has been conducted since the very beginning of the project. Although the development of the prototype has passed through three major stages, in this document we concentrate on an actual description of the device, of which 30 units have been produced, which have been installed and are fully operational at the experimental farm of IRTA (Figure 1). Information on the previous prototypes developed and tested it is available upon request.

Figure 1.- Feeding devices installed in the farm

The results in the document are structured as follows:

1. Wired installations to be conducted in the experimental farm.
2. Protection, mechanical and stability components of the feeding device.
3. Electrical components of the feeding device.
4. Software for real-time management of the feeding device.
5. Software for daily feed intake data processing.

In addition to these points, the document includes an appendix

6. Cleaning the feeding device and mounting protocol.

3. Results

3.1 Wired installations conducted in the experimental farm

The first action that has been conducted in the farm to fully use the feeding device was to provide power supply and network connection to each of the cages in which the feeding device will be installed. In IRTA's experimental farms in a module of 60 cages, 30 feeding device have been installed. To make optimal use of the devices, the feeding device can be used in two adjacent cages (Menegin, Pratica (8) 1,0P.) so that up to 8 kits per feeding device can be controlled. In these two adjacent cages, two 230V power supplies and two network connections have been provided. In addition to the feeding device, it is our intention to equip the experimental control cages with further monitoring equipment such as video cameras or sound recording systems (Figure 2).

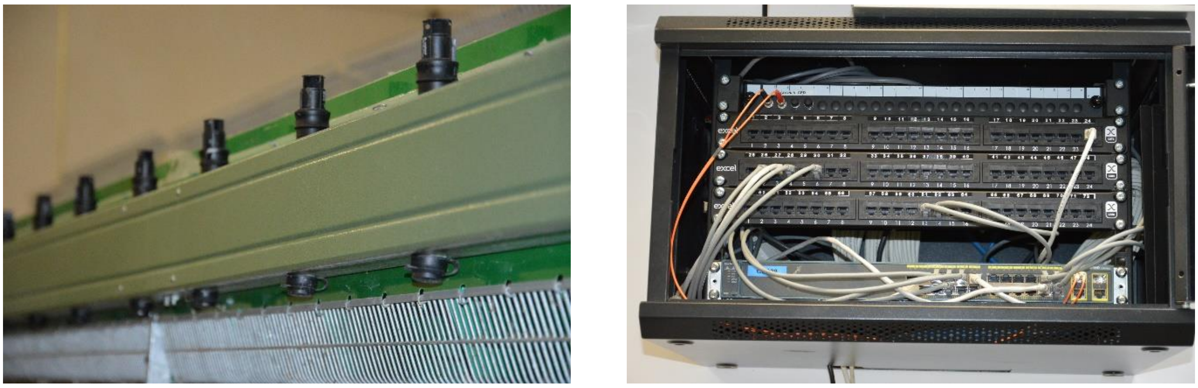


Figure 2.- Connector in each cage and communication rack for integrating the feeding devices to the server.

3.2 Protection, mechanical and stability components of the feeding devices

In this section, the physical hardware components of the feeding device needed to guarantee the correct working are described. They have been grouped in Protection (i.e., those components to avoid negative interactions between the device and the animals), Mechanical (i.e., components needed for providing feed), and Stability (i.e., to guarantee a reliable measurement of the weight of the feed in the scale).

Protection Components:

Given that the model of cage in which the feeding device has been developed is a polyvalent cage (i.e., used either as a growing or maternal cage), we have considered the easiest way to proceed to use the space reserved for the nest (when the cage is used as a maternal cage) as the space in which to allocate the feeding device (See Figure 3). In this situation, two protection mechanisms are needed.

Figure 3.- Place of the feeder in the cage. The separation between the living area for the rabbits and the feeder is seen, separating both areas.

2.1.- Protection of the whole area where the feeding device is placed. This is achieved using a polycarbonate plate, in which a hole has been created to allow the access just to the feeder. In this hole for the access to the feeder, a tunnel is placed to sort the animals entering the feeding device. The tunnel is designed in such a way that can be adapted to the size of the animals (See Figure 4).

Figure 4.- Polycarbonate pieces protecting the feeder and tunnel for sorting the access to the feeder.

2.2.- The second protection part aims to minimize the contact between the rabbit in the feeding device and the feeder (scale). It comprises a stainless steel piece fixed on the ceiling of the feeding device, and placed between the access tunnel and the feeder/scale (See Figure 5).

Figure 5.- Stainless steel piece protecting the scale (feeder) from the action of rabbits.

Stability Components:

The scale on which the feed falls is a stainless steel piece mounted on a load cell (See Figure 6). For a stable weight signal, the load cell needs to rely on a stable surface and the components have been designed to achieve this. All the components jointly constitute a pillar that goes from the floor to few centimetres below the cage, so that three long screws coming from the base of the scale can be connected to it. Thus, the three components of the stability components are:

1.- Stainless steel base for the pillar screwed to the wall of the manure ditch (see Figure 6a)

2.- Stainless steel pillar (see Figure 6b)

3.- Base for the scale, made of nylon. In this base, three screws connect the scale with the pillar (see Figure 6c), ensuring a stable connection with the floor if the barn.

a b

c

Figure 6.- Pieces of the pillar stabilizing the scale.

Mechanical Components:

The mechanical components are involved in the administration of the feed. The whole device for providing feed consists of a hopper (Figure 7), which is placed above a stainless steel platform, under which the scale is located.

The hopper consists of four components:

1.- Stainless steel hopper that can contain up to 3.5 kg of feed.

2.- In the base of the hopper and with an angle of 45º, there is a plastic screw (Figure 7), which is rotated by a 12V (14 rpm) motor to provide feed to the scale. This is done automatically once the weight of the scale is below a given threshold.

3.- In the upper extreme of the screw, a vertical pipe (figure 7) directs the feed to the scale.

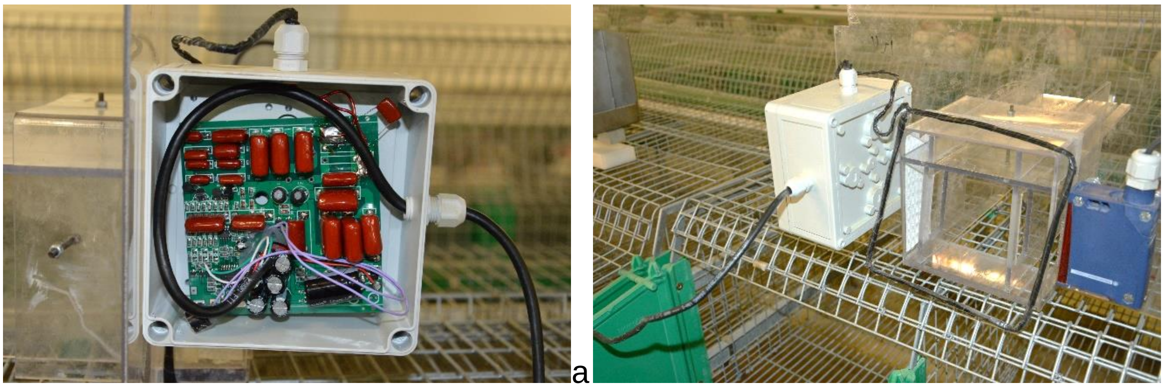
Figure 7.- Feed hopper and detail of the screw directing feed to the scale.

3.3 Electrical components of the feeding device

In this section, the electrical components of the feeding device are listed and briefly described. The list it is divided into peripheral and central electronic components.

Peripheral electronic components:

1. RFID reader (Figure 8): This device it is used for reading a tag that it is placed in the ear of the rabbit. The system works at 125 KHz and it has two components, the board (Figure 8a), which is located in an IP67 box, and the antenna made of a metal wire placed around the tunnel for accessing the feeder (Figure 8b).



a b

Figure 8.- RFID board and antenna.

2. Photoelectric Movement sensor (Figure 9): This device is used to physically control the access to the feeder. When the feeder is empty, this sensor sends 0; when the feeder is occupied, it sends 1.

Figure 9.- Photoelectric Movement sensor

3. Load cell (Figure 10):

Figure 10.- Load cell attached to the feeder

4. 12 V (14 rpm) Motor (Figure 11):

The motor to rotate the screw to provide feed it is located at the upper end of the base of the hopper. The motor is connected to the control unit and it can be activated either manually or automatically for a specified duration. In automatic operation, the motor is activated when the amount of feed remaining is below a given amount of feed.

Figure 11.- 12 V Motor and detail of its position in the feeding device.

Central electronic components:

The central electronic components are located in an IP67 box to which all the peripheral are connected. Also the power and network connections reach this box, in which the following components are integrated (Figure 12).

1. Home designed impress circuit to communicate electronically with all the components.
2. 12 V power supply (IRM-20-12).
3. Main board, including a main processor (ATMEGA2560)
4. Network board for wired connection (Ethernet W5100).
5. Relays. Used to activate the motor (ORWH-SS-112D1F).
6. RFID reader card. This is used to distinguish and identify the RFID devices in each cage.

7. HX711 card. To amplify the analogue signal taken by the load cell and make it readable for the processor.

Figure 12.- Central electronic components

3.4 Software for real-time management of the feeding device

The feeding device works as a scanner sending every second the status of all the sensors (i.e., scale, load cell, motor, photoelectric movement sensor, and RFID reader) to a server. Two sets of programs have been developed for the management of the feeding device: the ***internal software*** locally managing the feeding device, and a ***website interface*** to interact with the feeding device. In addition to this, a MySQL database has been developed to save the appropriate records.

The ***internal software*** (developed using the Arduino's programming language) is continuously running to perform the following functions:

1.- Scan the status of all the peripheral sensors.

2.- Interact with the server to receive any change in the parameters that control the behaviour of the feeding device.

3.- Activate the motor for providing feed when the level of the feed in the scale reaches a given threshold.

4.- The records that the system takes are placed in a memory buffer of up to 10 seconds and then the package is send to the sever.

The ***web interface*** allows monitoring the status of the different feeders (Figure 13). The web interface also allows providing feed manually to a given feeder, resetting the feeder, unlocking the motor, or taring the scale. It also allows checking the parameter configuration of that particular feeding device.

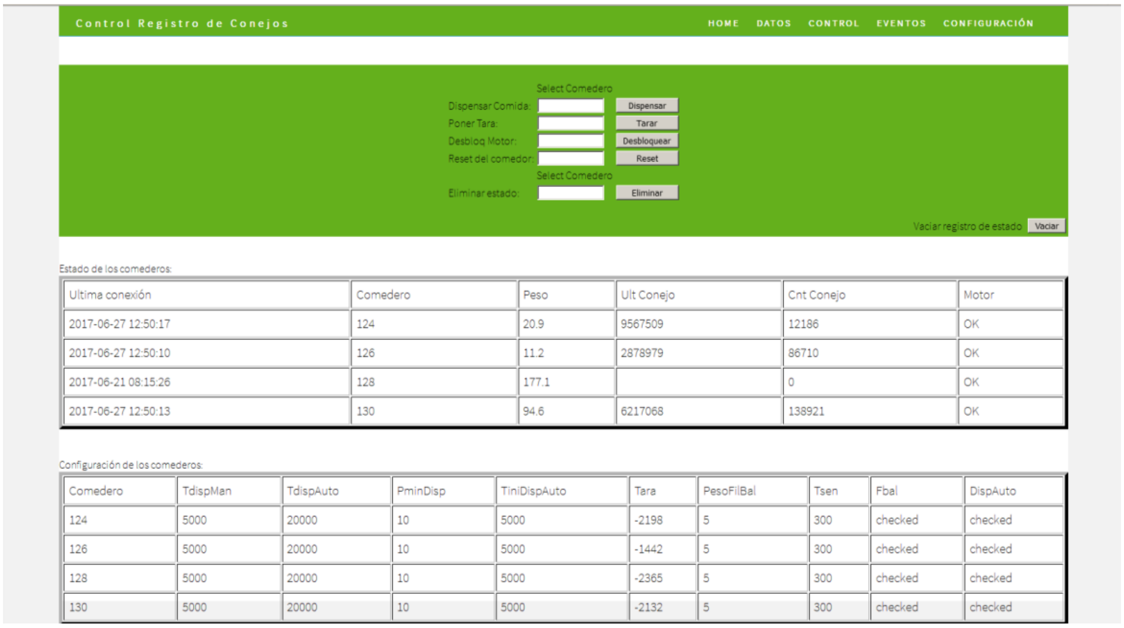


Figure 13.- Webpage for the control of the feeders. Its shows the current status of each active feeder and also provides some fields for real-time interaction with the feeder.

The web interface also offers a window with the last 100 records sent to the server (Figure 14).

Figure 14.- List of last 100 records send to the server.

In addition, a configuration page allows controlling many of the parameters involved in the function of the feeding device (Figure 15). For example, the weight of the scale at which feed is provided can be set. Daily time periods during which the feed provision is turned off can also be set. This function can be used in the case feed restriction would be applied.

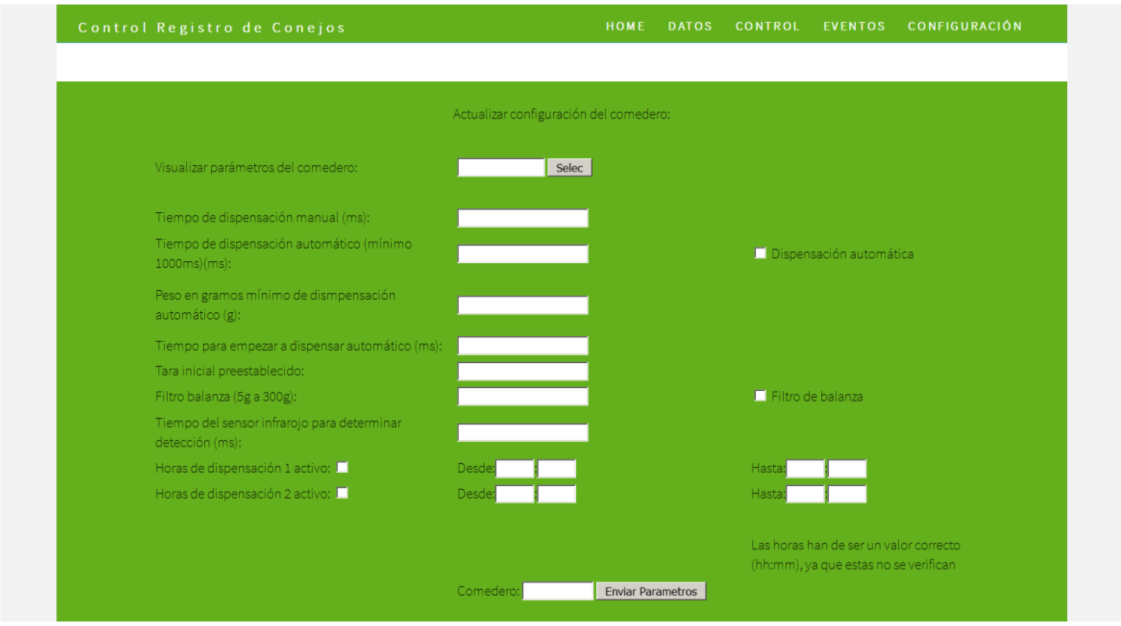


Figure 15.- Webpage for the parameter configuration of the feeders.

3.5 Software for data processing of daily feed intake

This software is automatically run once per day to obtain information about the different visits to the feeding device, and it can provide information on daily intake of individual animals. This information can be used to start measuring feed intake of each animal.

The software conducting this edition step was designed in R, and its major function is to define the visits to the feeder, which basically consist on retaining for each visit the ID of the animal entering to the feeder, the time and weight of the scale at the entrance, and the time and weight of the scale at exit. To conduct this edition, a number of issues have to be taken into account:

1.- Make sure that the visit can be assigned to an animal without error.

2.- The weights of the scale to be retained have to be taken so that the interferences by the animal on the reads are null or minimal. For example, the weight at the entrance has to be taken a few seconds before the animal actually gets into the feeder because once the animal is in the feeder, it may interfere with the signal the scale is sending. Something similar has to be done at exit; the weight retained should be a few seconds after the animal leaves the feeder, once the animal has completely left the feeder and the scale is stabilized around the new feed weight after the feed intake of that particular visit.

3.- Feed provision to the scale is a perturbation with respect to the signal the scale is sending to the feeder, this has to be considered when editing visits to the feeder.

After edition, information on visits would be available and plots similar to that shown in Figure 17 can be obtained.

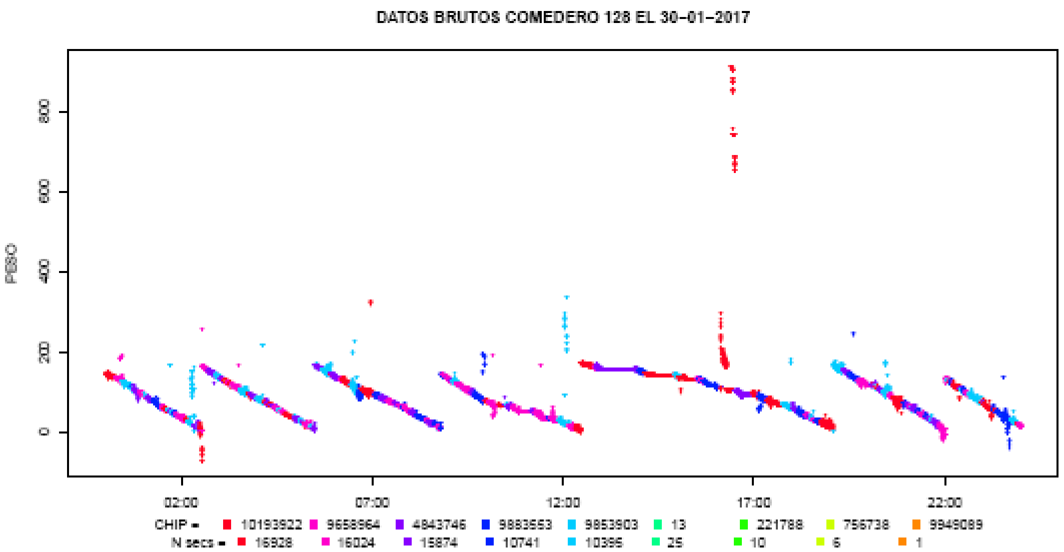


Figure 16.- Raw scale signal sent by the feeders to the server during 24 hours. Note that the interaction between the animal (different colours represent different animals) and the feeder, when the animal is inside the feeder makes the signal unstable.

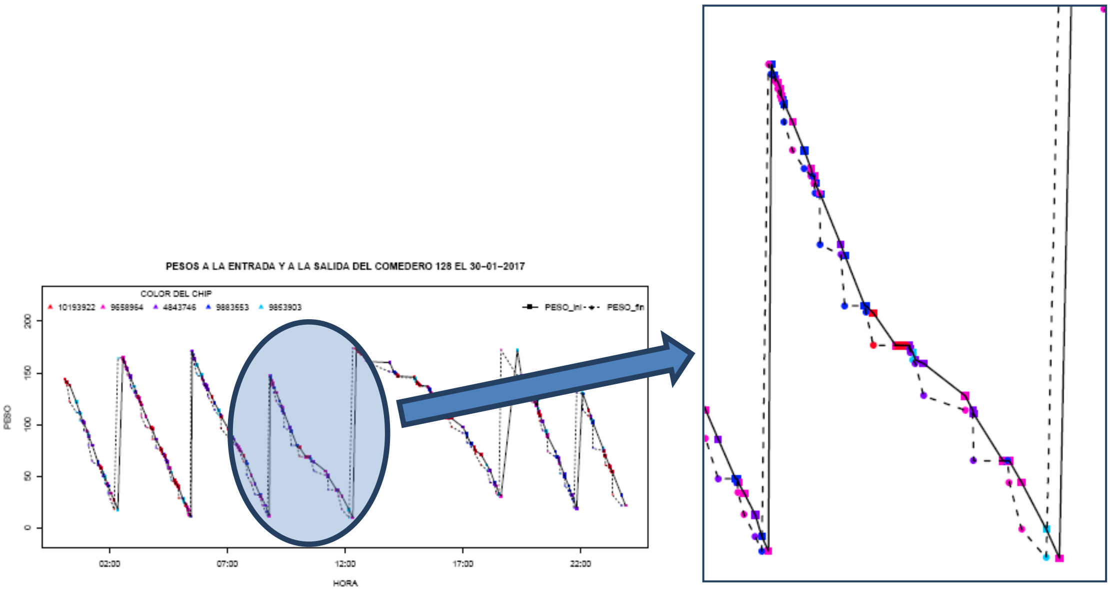


Figure 17.- Scale signal after visits to the feeder have been defined. The right panel represents zooms in on part of the left panel. The squares represent the weight at entrance and the circles weight at exit. Each pair represents a visit and the vertical difference between these two points is the feed Intake of a visit.

From the information in these plots, daily information on individual feed intake can be retained and used to compute individual feed intake during control periods. In the pig industry important efforts have been made to properly edit data at the level of the visits to the feeder (Eissen JJ, Kanis E, Merks JWM. Algorithms for identifying errors in individual feed intake data of growing pigs in group-housing. *Appl Eng Agric. 1998;14:667-673*) so that erroneous records at visit levels can be detected and removed. We are currently in the process of fine-tuning the edition of the visits, before computing daily records, to improve the quality of overall feed intake information provided by the feeders.

The information obtained from the software to daily edit raw data to define visits can be used for monitoring the functioning of the feeding devices during the fattening periods. The software is designed to automatically send reports by email to the farm manager to identify the feeding device that is not working properly.

4. Conclusions

1) All the feeding devices are installed and ready to be used, they allow controlling feed intake of up to 240 growing rabbits at a given time.
2) The feeding devices and the current versions of the software for processing the recorded data allow a reasonable recording of daily feed intake.
3) Protocols for management of the feeding devices (mounting, cleaning up, and monitoring) are available.

5. Annexes

ANNEX 1.- Feeding device cleaning and mounting protocol.

The day that the second weight control is conducted (Thursday) at 56 days of age, the procedure for cleaning up the installations and mounting back the feeding device is as follows:

1.- General electrical disconnection of all the feeding devices.

2.- Remove all the feeding devices from the cages. This will be done using two trolleys in which up to 18 feeding device can be allocated. The feeding device can be removed as a single piece. Only the feeder itself and the polycarbonate tunnel for accessing the feeder will remain in the cage. The first will be covered with a plastic bottle (to prevent getting wet while cleaning the cages) and the tunnel it is placed in the middle of the cage to cleaning up as well.

4.- Before implementing a standard procedure for cleaning the cages, an industrial vacuum cleaner is needed to remove all the remaining feed from the feeder. First, the hair needs to be burned, this has to be done with caution to avoid any damage to the scales and then a deep clean with hot water through a pressure washer will be done.

5.- Once the cleaning procedure is finished, the plastic protection covering the scales can be removed.

6.- All the feeding devices are placed back in their respective positions, this includes placing the tunnels for sorting the access to the feeder.

7.- Once everything has been mounted and before supplying power to the feeding devices, the option of automatic feed provision to the feeders has to be shut down.

8.- Provide power to the feeding devices.

9.- Once all the devices have been turned on, check for correct functioning. This is to be done at two different levels:

Checking at the PC whether the information that the feeding device sends to the server is correct or not:

a) The scale should be sending a value of zero. If this is not the case, the devices sending something different are annotated for further checking.
b) The occupation sensors should be sending zero. If this is not the case, it is likely that something blocks the signal. The feeding device yielding 1 will be annotated for further in farm inspection.

Checking in the farm those feeding device sending anomalous information:

a) Check that the scale is not in contact with any other component of the feeding device.
b) Check that the light controlling the movement sensor is not interrupted by any other component of the feeding device.

Once the movement and scale sensor signals have been verified, the RFID system can be checked. This will be done manually, passing a chip through the antenna and check whether a sound signal is emitted by the feeder. This indicates that the antenna is working properly. This procedure is to be repeated at the time of placing animals from the next batch in the cage.

10.- Once all the validations for the proper working of the device have been performed, the hoppers will be filled up with feed.

11.- In the server, the option for automatic feed provision can be re-activated, and approximately 150 grams of feed are then to be delivered to each feeder. If this is not the case, check (in the farm) whether there are problems with the connections of the motor for feed delivery.