UNIVERSITÀ DEGLI STUDI DI PADOVA

School of Agricultural Sciences and Veterinary Medicine

Department of Comparative Biomedicine and Food Science

Bachelor's degree course in Animal Care

Training and management of a captive Collared Peccary (*Pecari tajacu*) with Cardiomegaly and associated Weight Loss: a case study

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ACADEMIC YEAR 2025-2026

To Mom and Dad

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ABSTRACT

The management of captive wildlife presents significant challenges, particularly when dealing with understudied species affected by chronic clinical impairments. This case study aimed to enhance the welfare and behavioural repertoire of an adult female collared peccary (*Pecari tajacu*) housed at a sanctuary in Costa Rica. The subject suffered from severe obesity, cardiomegaly, and secondary ascites, which were severely exacerbated by an extremely sedentary lifestyle. The primary objective of the intervention was to promote weight loss and physical rehabilitation through a combined approach of dietary restriction and positive reinforcement target training to encourage movement. Due to safety protocols and the patient's enhanced complications, continuous diagnostic profiling and direct physical contact were unfeasible; consequently, data collection relied mostly on non-invasive, qualitative visual observations.

While the final weight loss did not meet the initial expectations due to necessary clinical interruptions and constraints, the project achieved key indicators of improved wellbeing. For example, post-crisis data revealed a good training success rate and a significant increase in spontaneous locomotion and environmental engagement, as confirmed by veterinary and staff members. These findings demonstrate that weight management in chronically ill captive animals is a multifaceted process where quantitative clinical metrics are most effectively interpreted alongside indicators of behavioural resilience and overall quality of life. Target training proved to be a viable, safe, and flexible tool for the physical rehabilitation of complex veterinary patients.

SECTION 1 – INTRODUCTION

1. GENERAL INFORMATION

The collared peccary (*Pecari tajacu*), known locally in Costa Rica as "*saíno*", is a medium-sized ungulate that serves as a vital ecosystem engineer across the Neotropics (Marinho et al., 2019; Beck, 2005). Its distribution extends from the Southwestern United States to Northern Argentina, encompassing a wide range of ecological conditions. Within the tropical rainforests of Central America, and particularly in Costa Rica, its ecological role has become a focal point for understanding forest dynamics and biodiversity conservation (Desbiez et al., 2009; Keuroghlian & Eaton, 2008).

1.1 Taxonomic Classification

The collared peccary (*Pecari tajacu*) belongs to the family Tayassuidae, a group of New World ungulates distinct from the Suidae (true pigs) of the Old World. Although peccaries were historically classified within Suidae due to morphological similarities, subsequent anatomical and molecular studies have supported their recognition as a separate family within the order Artiodactyla (Groves & Grubb, 2011). Taxonomic classification within Tayassuidae has undergone revision, particularly regarding the number of genera and species. Traditionally, three extant species are recognized: *Pecari tajacu*, *Tayassu pecary*, and *Catagonus wagneri*. Recent phylogenetic analyses have further clarified relationships within the group and reinforced the evolutionary divergence between peccaries and true pigs, highlighting their early separation in ungulate evolution (International Union for Conservation of Nature, 2023).

1.2 Distribution and Habitat Adaptability

One of the most defining characteristics of the collared peccary is its high degree of ecological tolerance (Marinho et al., 2019). Unlike the white-lipped peccary (*Tayassu pecari*), which is more sensitive to habitat disturbance, the collared peccary can exploit a wide range of environments, including primary and secondary forests as well as human-modified landscapes (Desbiez et al., 2009; Keuroghlian & Eaton, 2008).

1.3 Costa Rican Populations

In Central American ecosystems, including those of Costa Rica, populations have shown the capacity to persist in both protected and moderately disturbed habitats, reflecting a notable degree of ecological resilience (Keuroghlian & Eaton, 2008; Desbiez et al., 2009). However, the long-term effects of habitat fragmentation and environmental change remain areas of active investigation (Desbiez et al., 2009). The species is highly gregarious, typically forming stable social groups (Keuroghlian & Eaton, 2008). Nevertheless, group structure and size may vary in response to habitat conditions and resource availability, with more fragmented environments sometimes promoting reduced group cohesion or increased solitary behavior (Keuroghlian & Eaton, 2008; Desbiez et al., 2009). Local density estimates reported in the literature vary widely depending on habitat type, generally ranging from low to moderate densities, but are not directly comparable across studies due to methodological differences. The species is nevertheless classified as Least Concern by the IUCN Red List, suggesting relatively stable populations across its wide geographic range, although local declines have been documented in fragmented habitats.

1.4 Ecological Role and Impact in Costa Rica

Within tropical ecosystems, the collared peccary plays a significant role in shaping vegetation structure and ecosystem processes. Through activities such as rooting, trampling, and selective feeding, it contributes to the regulation of understory composition and plant regeneration dynamics (Beck, 2005; Desbiez et al., 2009). Peccary wallows - depressions in the ground filled with water and mud - act as focal points of ecological activity, supporting multiple species that rely on them for hydration and habitat (Keuroghlian & Eaton, 2008; Beck, 2005). In addition, their continuous disturbance of the forest floor promotes heterogeneity within leaf litter layers, facilitating nutrient cycling and influencing microhabitat availability for a variety of organisms (Beck, 2005; Desbiez et al., 2009).

1.5 Conservation and Challenges

Despite their ecological adaptability, collared peccaries face increasing pressure from deforestation and hunting, which can lead to local population declines and alter ecosystem dynamics (International Union for Conservation of Nature, 2023). In Costa Rica, they are frequently associated with protected areas, where conservation measures help mitigate these pressures. In addition to subsistence hunting, peccaries are targeted for their hides, which are valued in the international leather market (CITES, 2023). Although this trade may provide economic benefits to local communities, it raises concerns regarding sustainability and the risk of overexploitation, particularly in regions with limited wildlife management and enforcement (Bodmer & Pezo, 2001; Robinson & Redford, 1991; TRAFFIC, 2023).

Age class	Sex	Morphology	Physiology
Newborn **(0-2months)**	M/F	Brown-reddish unform coat, no collar; precocial locomotion (Sowls, 1997)	No thermoregulation and strong dependence on the mother (parental care) (Sowls, 1997)
Juvenile **(2-6 months)**	M/F	Progressive appearance of the light collar; rapid body growth (Emmons & Feer, 1997)	Gradual weaning and developing digestive capacity with gastric fermentation
Sub adult **(6-12 months)**	M/F	Morphology closer to the adult, well defined collar and start of dorsal gland development (Sowls, 1997)	Reach of sexual maturity and increase of glands activity for social communication (Sowls, 1997; Byers & Bekoff, 1981)
Adult (12+ months)	M	Greater body robustness and cranial development but not demanding canines as in Suidae (Emmons & Feer, 1997)	Full reproductive capacity, territorial and agonistic behaviour (Sowls, 1997)
Adult (12+ months)	F	Slightly smaller in dimensions, compared to males (moderate dimorphism) (Eisemberg & Redford, 1999)	Poliestral with gestation of ~138–145 days; 1-3 offsprings (Sowls, 1997; ADW, 2023)
Aged	M/F	Dental wear and tear reduction in body mass (Eisenberg & Redford, 1999)	Reduction of fertility and physiological performance (very limited data available)

Table 1.5.1, criteria for the classification of study individuals into age and sex classes based on morphological, physiological, and behavioural traits. The table outlines the chronological framework divided into five main stages, from newborn to senescence, used to determine the demographic structure of the population. For each cohort, key diagnostic field markers are provided. Relevant physiological milestones, including thermoregulation capacity, gastric fermentation development, reproductive parameters (gestation length and litter size for females), and behavioural traits (territoriality and social communication via gland activity) are synthesized. Primary literature sources and reference authorities are cited chronologically within the respective sections, but data availability is uneven across categories.

2. PHYSIOLOGY

2.1 General Physiological Characteristics of the Collared Peccary

The collared Peccari exhibits an integrated physiological profile typical of medium-sized tropical artiodactyls, combining metabolic regulation, thermoregulatory control, and digestive efficiency. Rather than extreme specialization, its physiology is characterized by functional flexibility across multiple systems, supporting survival in environments with variable resource availability and climatic conditions.

2.2 Metabolic Regulation

The basal metabolic rate (BMR) of the *Pecari tajacu* falls within the expected allometric range for mammals of similar body mass (McNab, 2008). However, overall energy balance in this species is not determined by metabolic rate alone, but also by the efficiency of digestive processing.

In contrast to strict grazers, which depend on high intake rates to satisfy their energetic requirements, peccaries adopt a different strategy: they combine moderate food intake with relatively efficient digestive processing, allowing them to extract sufficient energy even from low-quality, fibrous resource (Clauss et al., 2010; Vendl et al., 2016). This results in a metabolic system that is less dependent on continuous high-quality food intake, more resilient to fluctuations in nutrient availability and is closely linked to gastrointestinal retention dynamics.

2.3 Thermoregulation and Heat Dissipation

Thermoregulatory capacity in the collared peccary reflects adaptation to both tropical and semi-arid environments. The species relies on a combination of behavioural and physiological mechanisms to maintain thermal homeostasis. Physiologically, peccaries have limited sweating capacity and relatively low capacity for evaporative heat loss compared to some ungulates. As a consequence, heat dissipation is primarily achieved through peripheral vasodilation and panting. These physiological adaptations are coupled behaviourally with activity timing adaptation (crepuscular/nocturnal shifts in hot environments), use of shaded or forested microhabitats and wallowing behavior which enhances conductive and evaporative cooling. These mechanisms are essential in preventing hyperthermia, particularly in open or seasonally dry habitats (Keuroghlian & Eaton, 2008).

2.4 Water Balance and Osmoregulation

Water economy in *Pecari tajacu* is adapted to environments where free water may be intermittently available. The species demonstrates a mixed water acquisition strategy, combining direct drinking with indirect water intake from food. Key physiological aspects include efficient renal water conservation, tolerance to moderate dehydration and reliance on succulent plant tissues (e.g., roots, tubers, fruits).

However, unlike highly desert-adapted ungulates, peccaries are not fully independent of surface water, and water availability remains an important ecological constraint (Desbiez et al., 2009).

2.5 Digestive Physiology: Foregut Fermentation and Functional Organization

As a non-ruminant foregut fermenter, the species exhibits absence of rumination cycles, reduced anatomical specialization compared to ruminants and reliance on microbial fermentation for fiber digestion. This configuration imposes specific physiological constraints: energy acquisition depends on retention time and microbial activity, nutrient availability is influenced by fermentation efficiency, metabolic output is indirectly linked to gut function. Thus, overall physiological performance cannot be fully understood without considering the interaction between metabolism and digestive processing (Clauss et al., 2010; Vendl et al., 2016).

2.5.1 Foregut Fermentation as the Primary Digestive Mechanism

In *Pecari tajacu*, the initial stages of digestion are dominated by microbial fermentation occurring in the anterior compartments of the stomach. Ingested plant material is retained within these chambers, where symbiotic microorganisms break down structural carbohydrates such as cellulose and hemicellulose. This process results in the production of:

1. volatile fatty acids (VFAs) (primarily acetate, propionate, and butyrate)
2. microbial biomass
3. fermentation gases

VFAs represent the main source of metabolizable energy and are absorbed across the gastric epithelium, entering systemic circulation to support metabolic processes (Vendl et al., 2016).

2.5.2 Absence of Rumination and Its Functional Consequences

Unlike ruminants, the *Pecari tajacu* does not exhibit regurgitation and re-mastication of digesta. The absence of rumination has several physiological implications, such as reduced mechanical breakdown of feed particles after ingestion and consequent limited particle size reduction compared to ruminants and lower efficiency in processing highly lignified plant material. To compensate, peccaries rely more heavily on initial mastication efficiency, prolonged retention of digesta in the foregut, and sustained microbial activity. This results in a system that is less specialized but more flexible, particularly when processing mixed and variable diets.

2.5.3 Digesta Retention and Fermentation Efficiency

Retention time is a critical determinant of digestive efficiency in foregut fermenters. In *Pecari tajacu*, digesta remains in the gastrointestinal tract for extended periods (approximately 48-52 hours), allowing sufficient time for microbial degradation of fibrous components (López et al., 2014).

Unlike ruminants, the peccaries show a limited ability to selectively retain small particles within the foregut. In ruminants, fine particles and fluids are retained longer in the rumen, while larger particles are regurgitated and re-chewed, allowing for progressive size reduction and highly efficient microbial degradation. In peccaries, this selective retention mechanism is much less developed, the separation between liquid and solid phases of the digesta is relatively weak, and particles of different sizes tend to pass through the digestive tract more uniformly. As a consequence, there is less opportunity for repeated mechanical breakdown and prolonged microbial exposure of specific fractions of the ingested material.

This results in a digestive system that is less efficient in processing highly lignified plant components, but also less dependent on complex sorting and recycling mechanisms. Therefore, fermentation efficiency in *Pecari tajacu* is more directly influenced by factors such as diet composition, microbial activity, and overall passage rate, rather than by highly specialized retention dynamics (Clauss et al., 2010. Vendl et al., 2016).

2.5.4 Microbial Symbiosis and Functional Dependence

The microbial population is responsible for the breakdown of structural polysaccharides such as cellulose and hemicellulose into simpler compounds, which are subsequently fermented into volatile fatty acids (VFAs). These VFAs are then absorbed across the gastrointestinal epithelium and represent a major source of energy for the host. In addition, microbial metabolism contributes to the synthesis of microbial biomass, which can serve as a source of protein when digested downstream in the gastrointestinal tract. Microorganisms also produce essential micronutrients, including B-complex vitamins, further enhancing the nutritional value of the diet. Because of this functional dependence, digestive efficiency in *Pecari tajacu* is tightly linked to the stability and activity of its microbial community. Disruptions such as abrupt dietary shifts, low-quality feed, or environmental stressors can alter microbial composition and fermentation patterns, leading to reduced nutrient availability and impaired digestive performance (Clauss et al., 2010; Vendl et al., 2016).

2.6 Nutrient retention and absorption

2.6.1 Carbohydrates: Fermentation and Volatile Fatty Acids

Carbohydrates, particularly structural polysaccharides such as cellulose and hemicellulose, constitute a major fraction of the diet in the *Pecari tajacu*. These compounds cannot be hydrolyzed by endogenous enzymes and are therefore processed through microbial fermentation within the foregut compartments. During this process, complex carbohydrates are broken down by symbiotic microorganisms into simpler molecules, which are subsequently converted into volatile fatty acids (VFAs), mainly acetate, propionate, and butyrate (Vendl et al., 2016). These VFAs are rapidly absorbed across the foregut epithelium and represent the primary source of metabolizable energy for the host. Each VFA plays a distinct metabolic role: acetate is largely involved in peripheral energy metabolism and lipogenesis, propionate serves as a key substrate for hepatic gluconeogenesis, and butyrate is preferentially utilized by epithelial cells as a ~~local~~ energy source supporting tissue maintenance and function (Clauss et al., 2010).

Compared to ruminants, the efficiency of VFA production in *Pecari tajacu* is reduced due to the absence of rumination and a less effective retention of fermentable substrates. The shorter exposure of digesta to microbial activity limits the extent of fiber degradation. Nevertheless, this system remains sufficiently efficient to sustain energy requirements, particularly under diets where fibrous plant material predominates (Vendl et al., 2016).

2.6.2 Proteins: Microbial Transformation and Nitrogen Utilization

Protein digestion in the collared peccary involves a dynamic interaction between dietary protein intake and microbial metabolism. In the foregut, ingested proteins are partially degraded by microbial proteolytic activity into peptides, amino acids, and ammonia. These nitrogenous compounds are subsequently utilized by microorganisms for the synthesis of microbial protein. As microbial cells pass into the lower gastrointestinal tract, they are subjected to enzymatic digestion, releasing amino acids that can be absorbed by the host. This mechanism effectively converts low-quality or partially degraded dietary protein into a more standardized and biologically available protein source.

This system provides several functional advantages: it enables partial recycling of nitrogen within the digestive tract, reduces dependence on high-quality dietary protein, and links protein availability directly to microbial activity. However, unlike true ruminants, *Pecari tajacu* lacks highly efficient nitrogen recycling mechanisms such as urea recirculation to the foregut. As a result, protein utilization is more dependent on dietary intake and overall microbial efficiency, making the system less optimized but more flexible (Clauss et al., 2010; Vendl et al., 2016).

2.6.3 Lipids: Enzymatic Digestion and Interaction with Fermentation

Lipids represent a secondary but energetically dense component of the diet, particularly when derived from seeds and fruits. In *Pecari tajacu*, lipid digestion occurs primarily in the small intestine through host-mediated enzymatic processes involving bile salts and pancreatic lipases, which facilitate emulsification and hydrolysis into absorbable fatty acids and monoglycerides.

In contrast to carbohydrates, lipids are not significantly involved in foregut fermentation. However, their presence in the diet can influence microbial activity. Elevated lipid levels may inhibit certain microbial populations, particularly those involved in fiber degradation, thereby reducing overall fermentation efficiency. This effect is well documented in foregut fermenters and reflects a competitive interaction between lipid digestion and microbial fiber processing (Clauss et al., 2010). Consequently, a functional trade-off emerges; while lipids provide a concentrated energy source, excessive intake may impair the microbial breakdown of structural carbohydrates. This balance highlights the importance of diet composition in regulating digestive efficiency in the *Pecari tajacu*.

2.7 Digestive Efficiency and Physiological Constraints

The overall digestive efficiency of the *Pecari tajacu* reflects a balance between microbial fermentation capacity and structural limitations of the foregut system. As a non-ruminant foregut fermenter, the species achieves effective utilization of fibrous plant material, but with a lower degree of optimization compared to true ruminants (Clauss et al., 2010; Vendl et al., 2016).

A primary constraint lies in the absence of rumination and limited particle sorting mechanisms, which reduces the retention of fine, highly fermentable particles within the foregut. As a consequence, the extent of microbial degradation is constrained by relatively shorter and less selective retention dynamics. This directly affects fiber digestibility and overall energy yield from structural carbohydrates. In addition, digestive performance is strongly dependent on the stability and activity of the microbial community, making the system sensitive to variations in diet composition. Diets high in structural fiber require sustained fermentation, whereas increased intake of easily digestible carbohydrates or lipids may alter microbial balance and reduce fermentation efficiency. Despite these constraints, the digestive strategy of *Pecari tajacu* provides a significant adaptive advantage. Rather than maximizing extraction efficiency from a narrow range of resources, the system is optimized for functional flexibility, allowing the species to maintain energy balance across diets of variable quality. Thus, the digestive physiology of the *Pecari tajacu* can be best understood as a compromise between efficiency and adaptability, where moderate fermentation capacity is offset by the ability to exploit a wide spectrum of dietary resources.

3. FEEDING AND NUTRITION

3.1 Feeding ecology and adaptive strategy of the Collared Peccary

The collared peccary is a particularly noteworthy example of trophic generalist among Neotropical mammals. Recent studies have confirmed that the species exhibits considerable dietary plasticity, with marked variations depending on habitat, seasonality and resource availability (Keuroghlian & Eaton, 2008; Desbiez et al., 2009). This flexibility is a primary factor contributing to the species' wide distribution, which extends from semi-arid environments to tropical rainforests, including the ecosystems of Costa Rica. Comparative analyses demonstrate that peccaries are capable of rapidly adapting their diet composition in response to seasonal fluctuations, thereby maintaining a stable energy balance even under conditions of limited availability of highly nutritious resources. From a functional perspective, this strategy is based on the integration of behaviours that result as opportunistic feeding and the capacity to employ fibrous resources.

3.2 Diet composition and foraging behaviour

In the ecosystems of Central America, the diet of the collared peccary is predominantly herbivorous, but with a significant omnivorous component. The feeding behaviour of the Collared Peccaries is best described as facultative omnivore. Peccaries have been observed to consume invertebrates, small vertebrates and carcasses on occasion. While these components are quantitatively negligible, they may be significant regarding the intake of proteins and micronutrients.

Recent studies and contemporary databases (e.g. IUCN, 2023; Sowls, 1997; Beck, 2005) indicate that the diet consists primarily of young and mature leaves, roots and tubers, stems and fibrous plant material, fruits and seeds (when available).

In comparison to South American populations, where greater frugivory has been documented, Central American populations tend to rely more heavily on structural plant resources, reflecting differences in primary productivity and forest seasonality (Desbiez et al., 2009; Sowls, 1997).

An ecologically significant aspect is seed consumption: peccaries are able to process large, hard seeds due to the robust nature of their jaw muscles and well-developed canines (Beck, 2005). This ability makes the species being considered a key seed predator. Their impact is therefore not one-sided: some plant species may benefit from passing through the digestive tract, suggesting a dual role involving both predation and dispersal.

3.3 Social foraging and ecosystem engineering

Foraging is typically executed in social groups (sounders), a strategy that enhances efficiency in locating resources but also amplifies the local environmental impact.

Rooting and scavenging have been shown to have quantifiable ecological effects, including soil disturbance, increased mineralisation of nutrients, and changes in understorey structure. For this reason, the peccary is often considered an ecosystem engineer in tropical forests. (Keuroghlian & Eaton, 2008; Beck, 2005).

3.4 Ecological impact on plant communities

Through the selective consumption of plant species and destruction of seeds, peccaries (*Tayassu peccaries*) can physically disturb the soil in a targeted manner, and many studies have demonstrated their direct impact on forest regeneration processes (Beck, 2005; Desbiez et al., 2009). They can influence the composition of plant communities by favouring or limiting certain species. In particular, seed predation can reduce the dominance of certain plants, while soil disturbance can create environments that promote germination.

In tropical ecosystems, these effects contribute to regulating competition between species and increasing the structural diversity of the understorey (Beck, 2005; Desbiez et al., 2009).

3.5 Functional overview of digestive adaptations

From a functional perspective, the species is classified as a non-ruminant foregut fermenter, an intermediate state between monogastric and ruminant animals (Clauss et al., 2010; Clauss et al., 2010; Vendl et al., 2016).

The presence of anterior gastric compartments allows for:

- microbial fermentation of fibre
- utilisation of structural carbohydrates
- greater energy efficiency compared to simple monogastric

It is important to emphasise that this strategy allows the species to utilise resources of low nutritional quality and maintain flexibility in food selection.

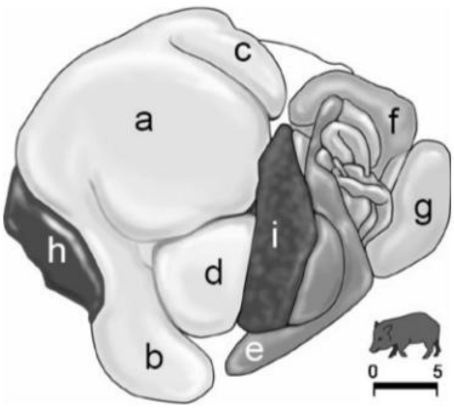

Figure 3.5.1: left ventral view of the stomach and associated visceral organs of the collared peccary (Pecari tajacu): a gastric pouch, b anterior and e upper blind sac, d glandular stomach, e caecum, f rectum, g bladder, h liver, i spleen. The scale bar represents 5cm. drawing by J. Peter, Zurich (A. Schwarm, 2009).

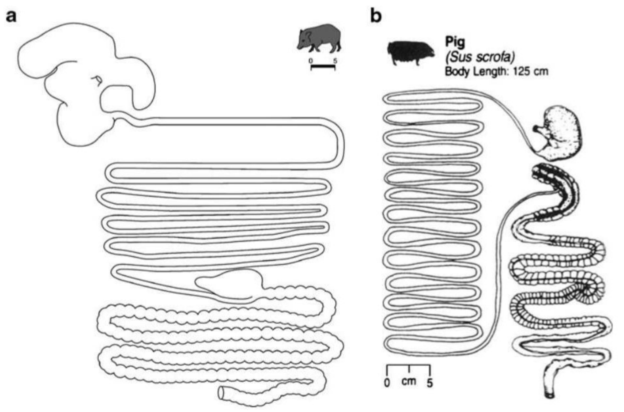

Figure 3.5.2: gastrointestinal tract of: a. collared peccary (Pecari tajacu). The scale bar represents 5cm. drawing by J. Peter, Zurich. b. wild boar (S. scrofa, Steven 1995). (A. Schwarm, 2009).

3.6 Functional Significance and Ecological Resilience

The integration of a flexible diet and fermentative capacity lies at the heart of the species' ecological success. Modern studies agree in describing this species as a resilient generalist, capable of occupying variable ecological niches and adapting to seasonal and environmental changes. This intermediate position between specialised herbivory and opportunistic omnivore constitutes a significant evolutionary advantage, particularly in tropical ecosystems characterised by high spatial and temporal variability of resources (Keuroghlian & Eaton, 2008; Desbiez et al., 2009; Vendl et al., 2016).

4. DOCUMENTED PATHOLOGIES

4.1 Pathologies in peccaries kept under human care

Although the collared peccary (*Pecari tajacu*) is considered a relatively adaptable species, individuals kept under human care may develop various pathological conditions related to stressors such as captivity, dietary changes and environmental constraints. While the available literature is limited and is often derived from broader studies on captive wild ungulates or Tayassuidae, several recurring health patterns have been documented.

One of the most relevant categories is nutritional and metabolic disorders. In captive settings, deviations from natural diets - particularly excess energy intake or imbalanced macronutrient composition - may lead to obesity or malnutrition. These conditions can have systemic consequences, including altered metabolic function and increased susceptibility to secondary diseases (Clauss et al., 2010; Fowler & Miller, 2015).

Gastrointestinal disturbances are closely linked to nutritional factors and may arise from inadequate fibre content or abrupt dietary changes. As foregut fermenters, peccaries rely on a stable population of microbes for efficient digestion. Disruption to this balance can result in reduced digestive efficiency, dysbiosis and gastrointestinal dysfunction (Vendl et al., 2016; Clauss et al., 2010).

Stress-related conditions are another significant concern in captive peccaries. Handling, confinement, social disruption and human interaction can trigger chronic stress responses with physiological consequences such as immunosuppression, altered metabolic regulation and increased cardiovascular strain. These effects may make individuals susceptible to various secondary conditions and indirectly contribute to the development of disease (Fowler & Miller, 2015).

Infectious diseases have also been reported, although data are relatively scarce. Peccaries may be susceptible to bacterial, parasitic and viral infections, particularly in environments where biosecurity is limited or where they come into contact with domestic species. Gastrointestinal parasites and opportunistic bacterial infections are among the most commonly reported conditions in captivity (Fowler & Miller, 2015).

Trauma and musculoskeletal injuries may occur, particularly if enclosures do not adequately replicate natural habitats. Limited space, inappropriate substrates or social aggression within groups can increase the risk of injury.

Finally, although rarely documented in detail for this species, cardiovascular disorders may occur in captive individuals and are potentially linked to chronic stress, metabolic imbalance or reduced physical activity. As with other mammals, these factors can contribute to long-term cardiac remodelling and functional impairment.

Overall, health disorders in peccary under human care are often multifactorial, arising from the interaction between environmental, nutritional and physiological factors. The limited species-specific literature highlights the need for a comparative and integrative approach that draws on principles from zoo and wildlife medicine to guide clinical interpretation and management.

Accordingly, this section focuses on cardiomegaly in *Pecari tajacu*, the central condition of this case study.

4.2 Cardiomegaly

Cardiomegaly is defined as an abnormal enlargement of the heart resulting from structural changes to the myocardium and/or cardiac chambers. It is not a primary disease, but rather a structural response of the heart to pathological or physiological conditions that impose chronic changes to its workload. From a structural perspective, cardiomegaly may arise through two principal mechanisms:

- Myocardial hypertrophy, characterized by an increase in cardiomyocyte size
- Chamber dilation, involving enlargement of one or more cardiac cavities

Myocardial hypertrophy can be further classified according to the nature of the hemodynamic load:

1. Concentric hypertrophy, typically associated with chronic pressure overload (e.g., systemic hypertension or outflow obstruction), resulting in increased wall thickness with relatively preserved chamber dimensions
2. Eccentric hypertrophy, generally associated with volume overload, characterized by dilation of the ventricular chambers with normal or reduced relative wall thickness

These structural adaptations reflect distinct pathophysiological responses to altered loading conditions and are associated with different functional outcomes.

In veterinary medicine, cardiomegaly is identified through diagnostic imaging techniques such as thoracic radiography and echocardiography, or through post-mortem examination. Assessment is typically based on the relationship between cardiac size and body size, as well as species-specific anatomical and physiological parameters.

4.3 Secondary Ascites Associated with Cardiomegaly

Secondary ascites is defined as the pathological accumulation of fluid within the peritoneal cavity resulting from systemic disorders that alter normal fluid balance. In the *Pecari tajacu*, ascites may develop as a consequence of advanced cardiac disease, particularly in association with cardiomegaly and impaired cardiac function (Ettinger et al., 2017).

4.3.1 Pathophysiological Mechanisms

In the context of cardiomegaly, ascites is most commonly associated with right-sided or congestive heart failure, in which the heart is unable to effectively return venous blood to the central circulation. This leads to an increase in systemic venous pressure, especially within the hepatic and portal systems (Zachary, 2017).

As venous pressure increases, the hydrostatic pressure within the abdominal capillaries also rises. This promotes the movement of fluid from the intravascular space into the interstitial compartment, and subsequently into the peritoneal cavity. Meanwhile, hepatic congestion further impairs venous outflow, aggravating fluid accumulation (Zachary, 2017).

In addition to these hemodynamic changes, reduced cardiac output results in renal hypoperfusion, which activates compensatory neurohormonal mechanisms, particularly the renin–angiotensin–aldosterone system (RAAS). Activation of this system leads to sodium and water retention, increasing circulating blood volume and further contributing to the development and persistence of ascites (Ettinger et al., 2017).

4.3.2 Relevance in the Collared Peccary

Although specific reports of cardiogenic ascites in the *Pecari tajacu* are limited, the underlying pathophysiological mechanisms are consistent across mammalian species. Therefore, similar processes are expected to occur when cardiac dysfunction progresses to the point of impairing venous return and fluid homeostasis (Clauss et al., 2010).

Clinically, affected individuals may present with abdominal distension, reduced activity and potential respiratory compromise due to increased intra-abdominal pressure.

The presence of ascites in association with cardiomegaly is generally indicative of advanced cardiovascular disease, with important implications for prognosis (Ettinger et al., 2017).

4.4 Dyspnoea Associated with Cardiomegaly

Dyspnoea is defined as a condition of laboured or difficult breathing, resulting from alterations in respiratory mechanics, gas exchange, or cardiovascular function. In the *Pecari tajacu*, dyspnoea may arise as a secondary consequence of cardiac disease, particularly in association with cardiomegaly and heart failure (Ettinger et al., 2017).

4.4.1 Pathophysiological Mechanisms

The increase in hydrostatic pressure within pulmonary capillaries promotes the movement of fluid into the interstitial space and the alveolar lumen.

This fluid accumulation reduces lung compliance and interferes with normal gas exchange, leading to decreased oxygen diffusion and ventilation–perfusion mismatch. As a result, affected animals experience increased respiratory effort and reduced oxygenation (Ettinger et al., 2017).

In addition, cardiomegaly itself may contribute mechanically to respiratory compromise: an enlarged heart can occupy a greater portion of the thoracic cavity, reducing available lung expansion, particularly in smaller-bodied species.

4.4.2 Functional Consequences

The combined effects of pulmonary edema and reduced lung compliance lead to: increased respiratory rate, increased respiratory effort, potential hypoxemia. These changes stimulate respiratory centers, resulting in the clinical manifestation of dyspnea. In advanced cases, inadequate oxygen delivery to tissues may lead to systemic consequences, including lethargy and reduced physical activity (Ettinger et al., 2017).

4.5 Transient Panting

Transient panting refers to a temporary increase in respiratory rate characterized by rapid, shallow breathing, typically occurring in response to thermoregulatory demands, stress, or transient physiological imbalance. In the *Pecari tajacu*, panting represents a normal physiological mechanism for heat dissipation but may also be observed in association with systemic or cardiovascular disturbances (Ettinger et al., 2017).

4.5.1 Physiological vs Pathological Panting

Under normal conditions, panting serves as a thermoregulatory mechanism, facilitating evaporative heat loss through the respiratory tract; it is particularly seen in species with limited sweating capacity. However, in the context of cardiomegaly, panting may occur as a secondary and transient response to alterations in oxygen demand or circulatory efficiency. Reduced cardiac output and impaired oxygen delivery can stimulate respiratory centers, leading to an increase in respiratory rate even in absence of overt pulmonary edema (Zachary, 2017).

It is important to distinguish panting from dyspnea. While dyspnea is characterized by labored and often distressful breathing, panting typically involves rapid but relatively shallow and less effortful respiration. Persistent or progressive panting may indicate worsening cardiopulmonary function and should be interpreted in conjunction with other clinical signs such as dyspnea or exercise intolerance (Ettinger et al., 2017).

4.6 Etiology of Cardiomegaly in the Collared Peccary (*Pecari tajacu*)

Cardiomegaly in the collared peccary should be interpreted as the consequence of underlying cardiac or systemic conditions rather than as an isolated pathological entity. While the structural mechanisms of cardiac enlargement have been previously described, the identification of potential etiological factors is essential for clinical interpretation and case analysis (Ettinger et al., 2017; Zachary, 2017). In domestic mammals, the most common causes of cardiomegaly include valvular disease, myocardial disorders, and chronic hemodynamic stress. Although species-specific data for *Pecari tajacu* are limited, these categories provide a useful comparative framework for evaluating cardiac enlargement in this species.

Valvular insufficiency represents a frequent cause of cardiac enlargement, leading to progressive volume overload and chamber dilation. Degenerative or inflammatory changes affecting cardiac valves can result in regurgitant blood flow, increasing cardiac workload over time (Ettinger et al., 2017).

Primary myocardial disease, including cardiomyopathies or inflammatory processes, may directly impair myocardial contractility and structural integrity. These conditions often lead to reduced cardiac efficiency and compensatory remodelling, which may manifest as generalized cardiomegaly (Zachary, 2017).

In addition, chronic systemic conditions may indirectly contribute to cardiac enlargement. In wild or captive peccaries, factors such as prolonged stress, nutritional imbalances, dehydration, and infectious disease can alter cardiovascular function and increase cardiac demand. These conditions may not directly affect the heart initially but can promote progressive cardiac adaptation over time (Kittleson & Kienle, 1998).

Environmental and management-related factors should also be considered. Captive conditions, including restricted movement, altered diet, and human interaction, may influence physiological stress responses and contribute to long-term cardiovascular strain.

It is important to recognize that these factors frequently interact, resulting in multifactorial pathogenesis. Therefore, cardiomegaly in *Pecari tajacu* is best understood as the outcome of combined influences rather than a single causative process.

This etiological framework is consistent with established principles of veterinary cardiology and provides a basis for interpreting the clinical findings described in the following case study (Ettinger et al., 2017; Kittleson & Kienle, 1998).

4.7 Clinical Management and Hospitalization of the Collared Peccary (*Pecari tajacu*)

The clinical management of cardiomegaly in the collared peccary requires a structured approach based on stabilization, monitoring, and minimization of physiological stress. Due to the limited availability of species-specific clinical data, management protocols are largely derived from established principles in veterinary cardiology, with necessary adaptations for non-domestic ungulates.

4.7.1 Initial Clinical Assessment

Priority should be given to the rapid evaluation of the animal's general condition, with particular attention to cardiovascular and respiratory function. Key clinical parameters include heart rate, respiratory rate, mucous membrane color, capillary refill time, and the presence of clinical signs such as dyspnoea, ascites, or lethargy.

In wild species such as *Pecari tajacu*, handling itself represents a significant physiological stressor. Therefore, clinical assessment should be performed efficiently and, when necessary, under controlled sedation to prevent exacerbation of cardiovascular compromise (Ettinger et al., 2017).

4.7.2 Stabilization

In individuals presenting with signs of congestive heart failure or respiratory distress, oxygen therapy is a critical first intervention, improving tissue oxygenation and reducing cardiopulmonary strain.

Fluid therapy must be approached with caution. While correction of dehydration may be necessary, excessive fluid administration can worsen cardiac overload and contribute to the development or progression of ascites and pulmonary congestion (Kittleson & Kienle, 1998).

Minimization of stress is a fundamental component of stabilization: environmental control plays a significant role in preventing additional cardiovascular demand.

4.7.3 Monitoring and Supportive Care

Continuous or repeated monitoring is essential during hospitalization. This includes assessment of heart rate and rhythm, respiratory pattern, and progression of clinical signs. Particular attention should be given to indicators of fluid accumulation, such as increasing abdominal distension or worsening respiratory effort.

When available, diagnostic tools such as ultrasonography or radiography can provide valuable information regarding cardiac size, presence of effusions, and pulmonary involvement. However, in many wildlife settings, access to advanced diagnostics may be limited, and clinical management must rely heavily on physical examination and observational data.

4.7.4 Species-Specific Challenges

The management of cardiomegaly in *Pecari tajacu* is complicated by several factors that can include: increased susceptibility to stress-induced physiological responses, difficulty in performing repeated clinical evaluations, limited reference values for physiological parameters and restricted access to species-specific pharmacological data.

4.7.5 Clinical Relevance

Overall, the principles of stabilization, controlled fluid management, and stress reduction are central to the successful management of cardiomegaly in the collared peccary. Although derived primarily from domestic animal medicine, these approaches provide a reliable framework for clinical decision-making in this species.

These general management principles form the basis for the clinical approach described in the following case study, where they are applied within the context of an individual patient.

SECTION 2 - CASE STUDY

5. OBJECTIVE

Based on the background provided in the introductory chapter, this case study focuses on a captive individual of collared peccary (*Pecari tajacu*) housed in a wildlife sanctuary in Costa Rica. The patient presents with clinical obesity complicated by underlying cardiomegaly. The primary objective of this study is to implement a management plan aimed at weight reduction while concurrently increasing the animal's physical activity, carefully considering its cardiovascular condition.

It is important to clarify that this project does not aim to provide an immediate or definitive solution to the animal's obesity, but rather to establish a functional starting point. Should this protocol yield positive outcomes, the sanctuary will continue the treatment to achieve a standard, healthy weight over time. This gradual approach is dictated by the clinical necessity for obese patients to lose weight progressively to avoid potentially severe side effects associated with sudden weight loss.

6. MATERIALS AND METHODS

6.1 Case description

The case concerns Camote, a seven-year-old female collared peccary (*Pecari tajacu*). Born in captivity, she was abandoned by her mother shortly after birth and subsequently hand reared. She was admitted to the rescue centre on 24 January 2019. Since then, she has been housed with a male peccary (Pechan), who was moderately overweight but did not present overt clinical disease. In May 2020, Camote was diagnosed with cardiomegaly via thoracic radiography. Her Vertebral Heart Score (VHS) was calculated at 11, which significantly exceeds the normal reference value of 8.55 established in *"Assessment of the VHS and Cardio-Thoracic Ratio to Standardize the Heart Size of Collared Peccaries"* (Osmar F. Silva-Filho, 2018). The following month, the patient presented with respiratory distress and concomitant ascites, secondary to cardiac dysfunction. This clinical presentation was consistent with congestive heart failure, a condition in which impaired cardiac function leads to fluid accumulation within body cavities. Following diagnosis, the patient was started on daily oral furosemide (Diurene, 4mg/kg per day), a loop diuretic used to manage congestive heart failure by promoting sodium and water excretion, thereby reducing fluid overload and alleviating signs such as ascites and pulmonary congestion. In March 2021, Enalapril (Cardial 0,5mg/kg, twice a day) was added to block angiotensin II, which constricts blood vessels. By blocking it, the blood vessels relax and dilate, allowing blood to flow more easily and the heart to pump more efficiently. In July 2025, following a re-evaluation, it was determined that the patient was significantly overweight (about

12 kg relative to the normal weight of an adult female peccary, 25 kg (Lochmiller et al., 1986; Sowls, 1997)). The furosemide dose was adjusted accordingly, and enalapril was replaced with Spironolactone and Benazepril (see Tab 6.1-1). Spironolactone, a potassium-sparing diuretic and aldosterone antagonist, was introduced to facilitate the elimination of sodium and water and reduce fluid retention, while Benazepril was added to dilate blood vessels, which lowers blood pressure, reduces the heart's workload, and reduces pressure within the kidneys. Administration of these drugs can be consulted in the following Table 6.1.1.

Medication, Active agent	**Total daily dosage**
Diurene (Furosemide)	4mg/kg – about 152 mg total per day *per os BID*
Cardial B5 (Benazepril + Spironolactone)	1 tab per 10kg – about 3 and 3/4 tablets per day *per os, SID*

Table 6.1.1, daily therapeutic plan for the patient. Medications are administered orally (per os), with the Furosemide dosage divided twice a day (BID) to maintain a stable diuretic effect, and Cardial B5 administered once a day (SID) due to the longer half-life of its active agents.

Due to administration constraints, specifically the safety requirement for zero direct contact, and the animal's inability to ingest tablets whole, the prescribed medications were crushed and mixed with mashed banana to ensure voluntary ingestion (in the morning and afternoon), while the animal was separated from the other.

The animal received a diet based on natural ingredients available on the site (Table 6.1.2).

ORIGINAL DIET			MODIFIED DIET	
Monday – Tuesday – Wednesday			**Monday – Tuesday – Wednesday**	
Ingredients	Grams x2	Grams x1	Grams x2	Grams x1
Papaya	102	51	120	60
Mango	104	52	40	20
Guava	104	52	232	116
Cucumber	148	47	120	60
Carrot	148	47	120	60
Green squash	148	47	/	/
Corn	148	47	392	196
Yucca (peeled)	148	47	176	88
Pecturin (not Monday)	Sprinkle	Sprinkle	Sprinkle	Sprinkle
Pig concentrate	450	225	212	106
Total	1500	750	1572	786
Thursday – Friday – Saturday – Sunday			**Thursday – Friday – Saturday – Sunday**	
Ingredients	Grams x2	Grams x1	Grams x2	Grams x1
Beetroot	148	74	/	/
Sweet potato	148	74	67 (cooked)	33(cooked)
Lettuce	148	74	/	/
Pumpkin	148	74	/	/
Broccoli stalks	148	74	/	/
Watermelon	104	52	/	/
Banana	102	51	408	204
Apple	104	52	180	90
Yucca (peeled)	/	/	427	213
Papaya	/	/	75	37
Cooked chickpeas	/	/	170	85
Pecturin (not Thursday)	Sprinkle	Sprinkle	Sprinkle	Sprinkle
Pig concentrate	450	225	160	80
Total	1500	750	1487	742

Table 6.1.2, comparison of weekly feeding schedule and dietary compositions for Pecary tajacu. The diet was divided into two distinct phases to ensure variety during the week and prevent habituation: (top) schedule for Monday, Tuesday and Wednesday; (bottom) schedule for Thursday, Friday, Saturday and Sunday. Feed amounts are expressed in grams and calculated based on the number of individuals (Grams x1 for a single animal, Grams x2 for two animals). The animal's diet consisted mainly of vegetables and fruit, supplemented with concentrated pig feed. Food amounts were calculated based on the average weight of a healthy adult individual. The revised feeding protocol (modified diet) was implemented on Wednesday, 1st of April, with a planned trial period of at least two months.

6.2 Clinical signs

The animal was noticeably overweight, with fat deposits evident from the mandibular region to the abdominal cavity, with particularly evident adipose tissue accumulation in the cervical region, along the thoracic flanks and pelvic girdle. Body condition score (BCS) was assessed using the 5-point numerical scale (ranging from 1=emaciated to 5=obese), adapted from standard wildlife scoring systems (Keep, 1971) and tailored to the anatomical features of the family Tayassuidae by evaluating the palpability of the ribs, vertebral processes, and pelvic bones.

Throughout her life, Camote reportedly exhibited a severely reduced level of locomotor activity. Although formal literature defining standard activity budgets in healthy collared peccaries is lacking, a comparative assessment with Pechan highlights a stark contrast. Based on this baseline comparison, Camote's behavioural profile can be characterized as highly sedentary and inactive beyond the fulfilment of basic biological needs.

Although responsive, Camote demonstrated diminished alertness and low reactivity to environmental stimuli, including enrichment items. Active awareness was rarely self-initiated, occurring almost exclusively following the behavioural cues of her male companion, but outside of this socially mediated response her baseline reactivity remained severely low. Behavioural observations indicated a profound lack of motivation, with minimal engagement in both environmental and social activities. Allogrooming and affiliative contacts were scarce and almost never initiated by Camote. Instead, Pechan actively sought her proximity and initiated most interactions. Notably, under perceived threat conditions, Pechan's behavioural repertoire shifted toward protective aggression directed at mitigating threats to himself and Camote.

To properly contextualize these findings, it must be noted that Pechan served as the intra-enclosure baseline for comparison. While individuals in captivity exhibit reduced activity budgets compared to their wild, wide-ranging counterparts, Pechan still displayed a functional range of exploratory and social behaviours. Consequently, Camote’s behavioural deficit is highlighted by the fact that her activity and motivation levels were significantly lower than those the co-housed conspecific already subject to the limitations of a captive environment.

Participation in target-based training sessions was inconsistent and when responsive, the animal required a long time to move between targets and displayed minimal engagement. Structured training was not implemented regularly, with only occasional maintenance session occurring once or twice per month. Consequently, no consistent exercise regimen was in place.

6.3 Training methods – Procedures and protocols

6.3.1 General Procedure and Target Training

All training sessions were conducted individually, following the physical separation of the animals into two distinct sections of the enclosure to ensure handler safety and prevent mutual interference.

Target training was implemented to stimulate active locomotion, promote spontaneous daily activity, and mitigate sedentary behavior. The target consisted of a long pole with a rigid plastic sphere at the distal end. The operator moved around the enclosure, positioning the target in various locations to prompt the animal to navigate toward it and make contact with it. A clicker was utilized as a secondary reinforcer to precisely mark and reward correctly executed behaviours. At the conclusion of each session, a standardized vocal cue consisting of the phrase "good job" followed by the animal's name, was delivered to signal the termination of the procedure.

6.3.2 Scale Training

Scale training was introduced to enable regular body weight monitoring without sedation. The procedure involved luring the animal onto the scale platform which was covered with synthetic grass to improve grip and increase acceptance using the established target and clicker reinforcement. If necessary, the target was placed directly on the platform and gradually raised to encourage the animal to stand on it completely. To facilitate access and eliminate the need to step onto an elevated object, the scale was later repositioned by embedding it directly into the ground, aligning the platform flush with the surrounding enclosure surface.

6.3.3 Heart Rate Monitoring

Heart rate monitoring training was conducted in a confined section of the enclosure. This setup allowed the animal to be safely positioned between a wooden log and a barred gate, providing the handler with protected access without physical restraint. The procedure required the animal to remain stationary while the handler placed a stethoscope against its thoracic region. A specific verbal cue ("*toco*") was consistently delivered prior to contact to signal the interaction and minimize stress. A second handler provided secondary reinforcement through targeting and clicker training, particularly when positional adjustments were required.

6.3.4 Injection Training

Injection training was developed to desensitize Camote to intramuscular (IM) anesthetic administration, aiming to reduce reliance on remote darting. This protocol was prioritized as a management safety measure due to the animal's severe obesity and underlying cardiomegaly case. Training was performed in the same setting and manner as cardiac auscultation to leverage the animal’s familiarity with the positioning and restraint-free immobility. Desensitization was structured to progress gradually across consecutive stages:

1. Tactile contact using a syringe without a needle.
2. Tactile contact using a blunted, non-penetrating needle.
3. Intramuscular injection using a standard needle with saline solution.
4. Injection of small volumes of a vitamin B solution to accustom the animal to the mild irritation sensation associated with anesthetic agents.

6.4 Treatment and management

Figure 6.4: visual representation of the action timeline and the relative organisation of the paper.

6.4.1 Initial observations

The initial two weeks were focused on monitoring the animal's behavior, routine habits, and behavioural patterns. While previous records were consistently verified, a significant discrepancy emerged regarding body weight. In March, the subject weighed 38.9 kg.

During this observation period, her movements were almost exclusively associated with feeding, with a notable absence of spontaneous exploratory or goal-directed behavior. Locomotion was restricted to essential physiological functions, which consistently occurred in a designated area of the enclosure. An additional observation was that every day a considerable proportion of the daily diet remained left over: in particular, beetroot, lettuce, carrot, broccoli stalks, and green squash were frequently left, accounting for approximately 500gr out of a total of 1500gr offered daily (twice a day). Given that approximately 450gr consisted of concentrate, this indicates that nearly one third of the total diet was not consumed. As a result, the actual intake was disproportionately composed of more palatable items, particularly sugary fruits. Further considerations relate to the distribution of the concentrate feed. This was provided in a single bowl per feeding session (450gr twice daily), shared between the two animals.

Both animals were trained to follow a target and to respond recognising their names. This ability was particularly useful for separating them between enclosures when required, especially during medication administration. It should be noted that banana was not included in the daily dietary ration but was used extra solely for this purpose, as the animal refused medication otherwise. The capacity of stepping on the scale and heart auscultation were still not assessed in this period.

6.4.2 Actions after observations

Following the initial two-week observation period, the first steps were to research to make a new diet and develop an effective training approach. This aimed to gradually familiarise the animal with the presence of a new handler, promoting calm and cooperative interactions. Initially, training sessions were supervised by the Alturas manager, who provided practical guidance on handling techniques and session structure. Subsequently, the manager allowed independent work. Trainings were performed over a 9-weeks period.

The behavioural conditioning programme was structured around low-intensity exercises designed to accommodate Camote's severe obesity and cardiomegaly; consequently, high-intensity activities (e.g., running or jumping) and rapid weight loss were avoided to prevent potential cardiovascular overexertion.

Sessions were held consistently with at most one or two rest days per week, primarily during the cooler hours of the early morning (~07:00 AM) and late afternoon (~05:00 PM) to reduce thermal stress, coinciding with routine management and medication delivery. Occasional sessions were also conducted between 01:00 PM and 02:00 PM.

Participation remained entirely voluntary, with session duration and intensity continuously adapted based on the animals' motivation and panting episodes, which served as indicators of fatigue. Positive reinforcement was achieved using feed components (bananas and yucca) taken directly from their daily rations to ensure caloric control. Although the protocol specifically targeted Camote's clinical condition, Pechan was target-trained as well to provide enrichment.

A specific compliance score was developed to quantitatively evaluate the animal's responsiveness. Compliance was measured as a categorical score ranging from 1 to 4, derived directly from the success rate of each training session. The success rate (S) for each session was calculated as the ratio of successful attempts (H) to the total number of initiated attempts (T), provided that $T > 0$: $S = H/T$.

Based on this percentage, individual sessions were categorized into a four-tier compliance scale using the following criteria:

- Score 1 - Low compliance: $S < 25\%$
- Score 2 - Moderate compliance: $25\% \leq S < 50\%$
- Score 3 - High compliance: $50\% \leq S < 75\%$
- Score 4 - Excellent compliance: $S \geq 75\%$

NOTE: blood samples were processed by VetLab (San José, Costa Rica). To ensure diagnostic accuracy, the reference intervals used for the clinical evaluation of the subject were provided directly by the analysing facility, corresponding to the specific laboratory reagents and autoanalyzer utilized.

7. RESULTS AND DISCUSSION

7.1 Respiratory signs

Throughout the observation period, Camote was found in sternal or lateral recumbency within shaded zones. She transitioned out of rest solely to feed or to move between enclosures for medication delivery. This profound lethargy and high level of inactivity persisted even during the cooler hours of the early morning and late evening. During baseline observations at rest, Camote’s respiratory effort was visually more pronounced and accelerated compared to that of Pechan, despite the latter's smaller size and lower body mass. During the initial two weeks of the observation period, panting episodes were recorded on only three occasions, related to the hottest hours of the day. These episodes typically lasted between five and ten minutes, though longer durations had been occasionally noted prior to this formal tracking period. Conversely, from the end of the third week to the beginning of the fifth week, heavy panting was observed daily, occurring indiscriminately of the time of day, ambient temperature, or physical activity. During these severe episodes, Camote remained recumbent in shaded areas, occasionally repositioning herself or engaging in soil-digging behavior. The uniform lethargy observed in Camote represents a baseline behavioural state driven by a severe, self-reinforcing pathological cycle rather than external variables. At the core of this loop, the underlying cardiomegaly acts as the primary physical constraint, drastically reducing exercise tolerance and mobility. The resulting minimal daily energy expenditure, combined with consistent food availability, led to progressive weight gain. This increasing body mass completed the vicious feedback loop, further reducing mobility and significantly escalating the mechanical and metabolic workload on an already compromised cardiovascular system. To the authors' knowledge, this specific self-reinforcing pathological loop has not been previously reported in collared peccaries (*Pecari tajacu*). However, swine models are widely utilized to study these dynamics: chronic physical inactivity combined with metabolic overload is proven to induce rapid weight gain, cardiac hypertrophy, and severe exercise intolerance, perfectly replicating this vicious cardiovascular loop (Spadaccio et al., 2024).

The subsequent shift from sporadic panting to daily, indiscriminate respiratory distress indicates a transition into periodic clinical crises. Because these severe episodes occurred independently of ambient conditions or physical effort, they are directly linked to her cardiac condition and the mechanical compression of the thoracic cavity by visceral fat. To the authors' knowledge, detailed records of progressive cardiorespiratory complications in collared peccaries (*Pecari tajacu*) are absent in current literature. However, in comparative swine models (*Sus scrofa domesticus*), this transition to persistent, non-exertional respiratory distress strongly suggests advanced congestive heart failure. These crises may reflect underlying pulmonary venous hypertension, pleural effusion, or alveolar atelectasis from macro cardiomegaly compression (Cruz et al., 2019). Furthermore, secondary ascites could have compounded this restriction: the accumulation of abdominal fluid, working synergistically with visceral fat, increases intra-abdominal pressure and forces the cranial displacement of the diaphragm, severely reducing lung capacity and leading to terminal ventilation-perfusion mismatch (Vesco et al., 2021). Within this context, the documented soil-digging behavior could be interpreted as serving a dual purpose: as an instinctive attempt to seek cooler ground to mitigate metabolic heat retention, and potentially as a behavioural displacement activity driven by physical discomfort (Bracke et al., 2011; Mason et al, 2007).

7.2 Weight

On March 11, the animal's body weight was recorded at 38.9 kg, confirming severe obesity and a Body Condition Score (BCS) of 5/5. This followed a weight gain trajectory between July 2025 and March 2026, during which the animal gained nearly 2 kg within an 8-month span without any dietary alterations or management changes.

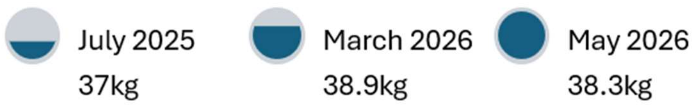

Figure 7.2.1: timeline of body weight variations of the subject across three key experimental checkpoints (July 2025, March 11, 2026, and May 28, 2026). The circular indicators illustrate an initial weight gain from 37.0 kg to 38.9 kg, followed by a reduction to 38.3 kg in the final phase.

Following the implementation of the dietary protocol, direct on-site monitoring concluded on May 15. Due to logistical constraints and temporary shortages in anaesthetic supplies, the final weight could not be acquired before the investigator's departure. Consequently, the clinic staff recorded the follow-up weight two weeks later, on May 28, recording a final mass of 38.3 kg. This represents an overall weight loss of 600 grams, achieved across the nine-week management period. Post-project veterinary reports subsequently noted a visible increase in Camote's baseline activity levels compared to the pre-project period.

The animal's rapid weight gain before the study highlights how easily she accumulated excess fat under the previous management conditions and clinical status. In this context, although the subsequent recorded weight loss of 600 grams might appear modest in absolute terms, a gradual reduction of approximately 1.54% of the total body mass represents an appropriate therapeutic approach for this subject. In obese individuals, rapid weight loss poses a severe risk of adverse metabolic complications, most notably hepatic steatosis (Corn & Warren, 1985; Lochmiller et al., 1986). Therefore, this controlled, gradual decline confirms the safety and efficacy of the dietary restriction protocol. This clinical improvement is further supported by the post-project veterinary reports detailing a visible increase in baseline activity. This heightened mobility is a crucial indicator of improved welfare, suggesting that the weight loss process successfully started and enhanced the animal's physical conditioning.

7.3 Diet

A key component of the management strategy was modifying the diet. As detailed nutritional formulation was beyond the scope of this study, dietary adjustments were carried out in collaboration with the head veterinarian. Based on the feeding behavior of the two co-housed animals and supported by literature on species-appropriate feeding, a revised diet was formulated (Table 6.1.2).

Observations indicated that the individual reaching the bowl first tended to consume most of the feed; specifically, Pechan was observed to eat more rapidly, whereas Camote consumed food more slowly. The revised feeding protocol was implemented on Wednesday, April 1st, with a planned trial period of at least two months. The formulation of the revised dietary regime required careful balancing of the nutritional needs of both cohabitating animals, tailored specifically to Camote's clinical condition. The new diet included a significant reduction in commercial pig concentrate combined with an increased proportion of banana. Unripe (green) bananas were specifically selected to limit simple sugar intake, while successfully maintaining the overall palatability of the meal. Furthermore, bananas and yucca played a highly practical role in facilitating training sessions and daily medication administration, as they represented the two feed the animal consistently and voluntarily consumed. This allowed handlers to vary the items used during conditioning without disrupting caloric boundaries. Protein intake was qualitatively adjusted by partially shifting it from commercial concentrate feed to a more natural, whole-food source: boiled chickpeas. This modification was introduced considering suspected difficulties in protein digestion and assimilation, which may affect animals under prolonged metabolic stress. Chronic metabolic overload and systemic strain are known to compromise gastrointestinal mucosal integrity and enzymatic efficiency in suids, potentially impairing the absorption of complex commercial protein concentrates (Pearce et al., 2013). Consequently, substituting commercial feed with cooked legumes could provide a more physiologically suitable and highly digestible protein source. Boiling process significantly enhances the protein digestibility coefficient of legumes by denaturing structural proteins and inactivating heat-labile antinutritional factors, thereby ensuring adequate assimilation without exacerbating intestinal strain (Alajaji & El-Adawy, 2006). However, a practical challenge arose during the implementation phase, as individual differences in feeding behavior made it difficult to accurately quantify individual intake. To mitigate mutual interference and ensure a more equal distribution, the concentrate food was divided into two separate bowls. Additionally, the feed was wetted with water to alter its powdery constitution and intentionally increase eating time and effort.

7.4 Blood analyses

Blood samples were collected during the anaesthetic procedure and submitted for laboratory analysis, expressed in Table 7.4.1:

	March 12	May 28	Range
Cholesterol mmol/L	2.54	2.56	3.42 – 9.72
Cholesterol LDL mmol/L	0.43	0.51	NR
Cholesterol HDL mmol/L	1.89	1.70	NR
Triglycerides mmol/L	0.40	0.15	0.12 – 0.72
Glucose mmol/L	5.8	5.4	4.00 – 14.79
Urea mmol/L	2.44	/	5.0 – 16.8
Total proteins g/L	74	/	68-91

Table 7.4.1: blood metabolites concentration observed in Camote, confronting samples collected on March 12 and May 28, and reference ranges provided by the lab that conducted the analysis.

It's possible to observe reduced urea and cholesterol levels in both exams which appeared inconsistent with the animal's marked obesity. A preliminary interpretation of the metabolic data suggests that: reduced urea levels may be associated with low protein intake or altered protein metabolism and hypocholesterolaemia may be related to enteropathies with protein loss or potential hepatic dysfunction.

A substantial decrease is observed in serum triglycerides, which dropped significantly from 0.40 mmol/L in March to 0.15 mmol/L in May, indicating active lipid utilization for locomotion rather than fat storage. This trend is corroborated by the dynamics of cholesterol fractions. In both periods, High-Density Lipoprotein (HDL) levels (1.89 mmol/L in March and 1.70 mmol/L in May) remained substantially higher than the Low-Density Lipoprotein (LDL) fractions (0.43 mmol/L and 0.51 mmol/L, respectively). While total cholesterol (2.54 mmol/L and 2.56 mmol/L) remains stable yet slightly below the standard reference range (3.42 – 9.72 mmol/L), this profile aligns with the subjective homeostatic baseline typical of adult female peccaries (Lochmiller & Grant, 1984). Lastly, serum glucose levels show a downward trend from 5.8 mmol/L to 5.4 mmol/L, remaining safely within the physiological reference range (4.00 – 14.79 mmol/L) and confirming enhanced insulin sensitivity stimulated by increased physical activity.

Range values: VetLab, 2026, reference intervals for veterinary haematology and biochemistry diagnostics. Clinical report reference guidelines. San José, Costa Rica.

The reduced urea levels in March and hypocholesterolaemia observed across both exams appeared inconsistent with the animal’s marked obesity. Clinically, lower urea levels are frequently associated with low protein intake or altered protein metabolism, while hypocholesterolaemia can relate to enteropathies with protein loss or potential hepatic dysfunction (Thoresen et al., 2013). However, because total protein values in March remained within physiological boundaries, protein malnutrition or severe metabolic impairment appear less likely, suggesting that the restricted caloric intake successfully promoted targeted fat tissue catabolism without compromising lean body mass, as controlled energy restriction in suids is documented to lower circulating lipids without inducing systemic protein depletion (Müller et al., 2021).

The sharp contraction of serum triglycerides is the most prominent biochemical finding. Rather than indicating a nutritional deficit, this marked reduction reflects a highly efficient shift in energy partitioning. Under the combined influence of the optimized diet and the physical enrichment protocol, available energy was actively channelled into locomotion and skeletal muscle expenditure rather than being directed toward adipose storage (Lochmiller & Grant, 1984; Bezerra et al., 2024).

This fat-mobilization phase is dynamically supported by cholesterol fraction trends. The clear predominance of HDL over LDL suggests that Camote maintains the standard cytoprotective and anti-atherogenic lipid architecture typical of wild peccaries (Lochmiller et al., 1985; Bezerra et al., 2024).

Furthermore, the concurrent slight elevation in circulating LDL and minor reduction in HDL may serve as a potential indicator of active lipolysis, reflecting the systemic mobilization of stored lipids (Adan et al., 2021). As the subject transitioned out of an energy-surplus state, peripheral adipose tissue was actively catabolized, temporarily shedding low-density lipoproteins into the bloodstream during this successful weight-loss trajectory (Corn & Warren, 1985; Lochmiller et al., 1986). While total cholesterol values remained slightly below the generic reference range, this stable profile could align with the specific, healthy homeostatic baseline typical of adult female peccaries, who naturally exhibit lower baseline concentrations than males (Lochmiller & Grant, 1984).

Finally, the downward trend in blood glucose further corroborates the systemic benefits of the exercise plan. This shift points toward enhanced insulin sensitivity, as regular physical activity systematically optimizes glucose uptake by skeletal muscle tissues, preventing insulin resistance and stabilizing blood sugar within a narrower, highly efficient operational range (Lochmiller & Grant, 1984).

7.5 Training

The time spent in training sessions is reported in following Figure 7.5.1:

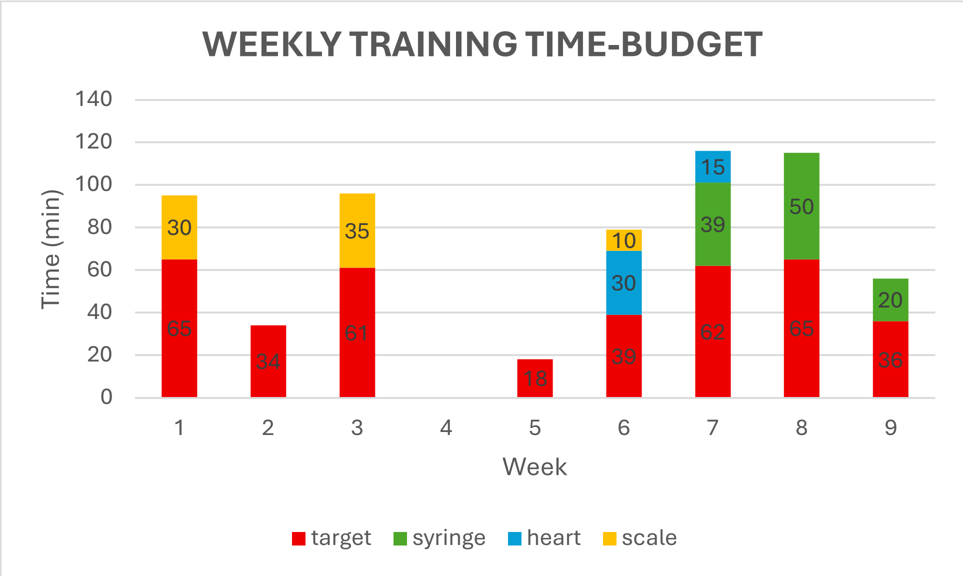

Figure 7.5.1: this stacked column chart illustrates the weekly time dedicated (in minutes) to various training categories. The total height of each column represents the cumulative weekly volume, while individual segments display the time distribution among different activities (target, syringe, heart, and scale). After initial fluctuations in Weeks 1–3 (ranging from 34 to 96 minutes), training was completely suspended during Week 4 due to severe panting episodes. Following a minimal restart in Week 5 (18 minutes), a significant volume increase is observed between Weeks 6 and 8, peaking at 116 minutes in Week 7, which directly coincides with the introduction of new medical conditioning components (heart and syringe). In total, Camote was trained for 609 minutes (equivalent to 10.15 hours).

Although it is not possible to visualize a linear pattern or steady improvement, considering the patient's severe clinical conditions and behavior, the protocol is considered a successful improvement in movement, particularly regarding target training. During Week 4, Camote was completely unable to stand or undergo any training. Any attempt raised significant clinical and welfare concerns, as it was feared she could not tolerate the physical exertion. Following the cautious restart during Week 5, however, the animal unexpectedly exhibited good levels of activity in the subsequent weeks. This fluctuation in the data does not indicate a failure; instead, it directly reflects Camote’s willingness to participate and her gradual physical improvement.

It is important to note that the operator's response to the animal leaving was strictly dependent on its behavior. When Camote left the session while visibly panting, seeking shade, or lying down, experience showed that she would not resume training. Conversely, if it moved away to sniff the surroundings or forage for leftover food, it typically returned after a short period; in these cases, waiting for it to resume the activity proved productive. Regardless of the outcome, these waiting intervals were systematically included in the total duration of the training sessions.

- Target

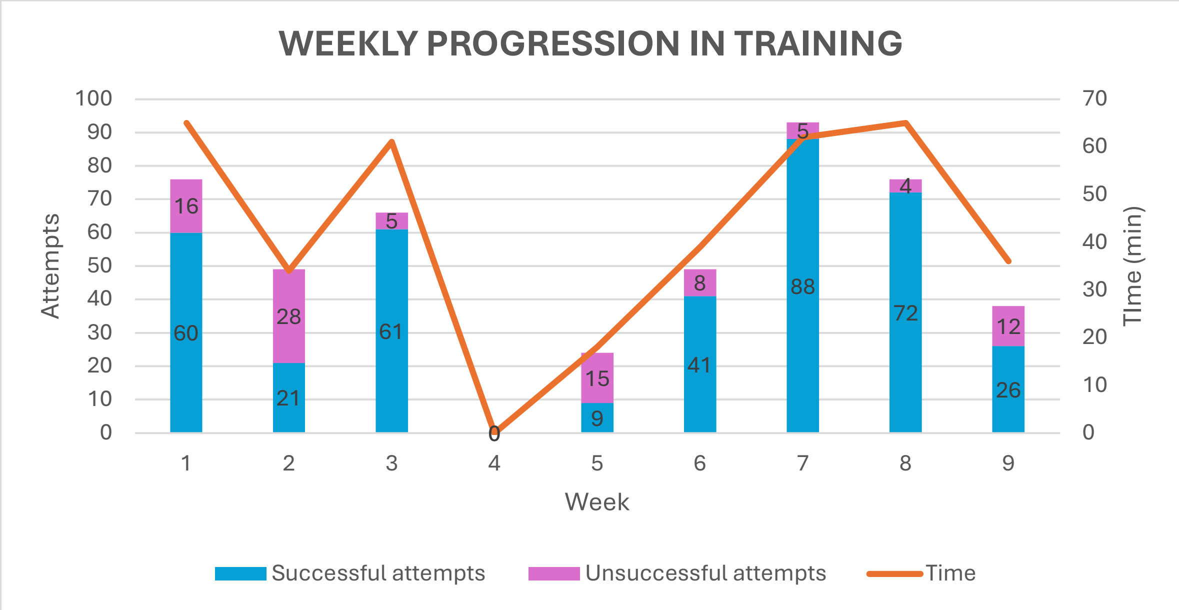

Figure 7.5.2: this chart illustrates the weekly training time (orange line) against successful attempts (blue segment), and unsuccessful attempts (violet segment). An "attempt" is defined as the trainer positioning the target, while a "successful attempt" occurs when the animal touches the target, achieving the training objective. The data shows a progressive increase in successful attempts relative to unsuccessful ones, particularly during Weeks 6, 7, and 8. Notably, a comparison between Week 1 and Week 8 reveals an identical training time and total number of attempts (76), yet a higher number of successful attempts (72 vs. 60) in the final period.

Figure 7.5.2 shows that the animal became capable of performing a higher number of successful attempts within the same time frame. Aside from the exact numerical correspondence between Week 1 and Week 8, the general trend shows an increase in successful attempts relative to both time and total attempts. This progression suggests increased motivation, focus, and movement speed, likely driven by a renewed interest in exploring and participating more actively in the sessions.

This quantitative improvement aligns with qualitative observations recorded during the final weeks: the animal appeared significantly more focused on the target and less distracted by her surroundings. For instance, Camote began moving confidently over physical obstacles rather than around them, consciously choosing the shortest route to reach the target even when it required greater physical exertion.

Target training success rate and compliance

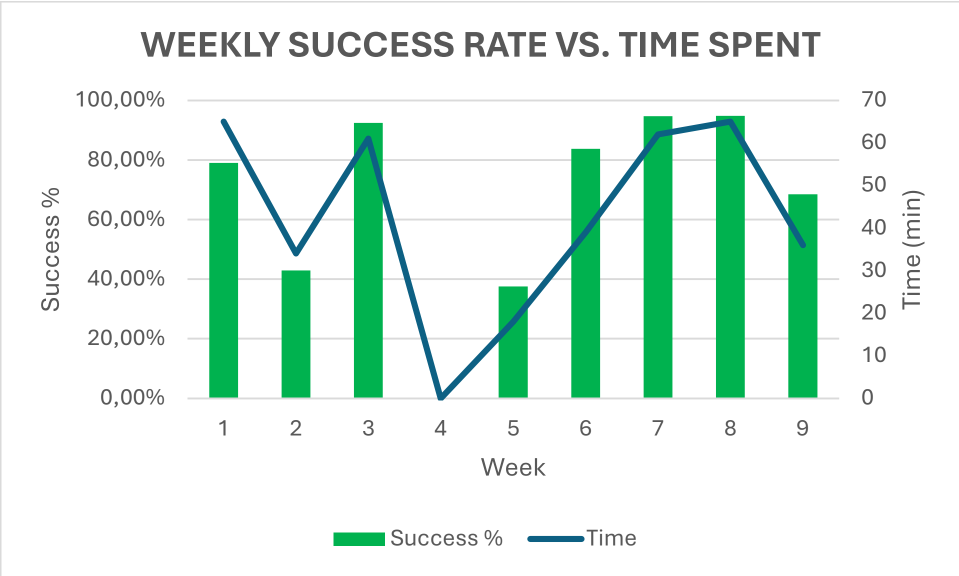

Figure 7.5.3: this chart displays the weekly success rate (green columns) and the training time spent (blue line). During the baseline period (Weeks 1 to 3), the success rate started at 78.95% and peaked at 92.42% in Week 3, with a significant drop to 42.86% in Week 2. Following a drop to 0.00% during the Week 4 suspension, the success rate stood at 37.50% upon reintroduction in Week 5. In Week 6, the success rate climbed back to 83.67%, leading into a plateau of maximum operational efficiency in Weeks 7 and 8, where it peaked at 94.62% and 94.74%, respectively, before a final decline.

The interaction between the weekly success rate, behavioural compliance, and the time spent training highlights a progressive optimization of Camote's learning retention and movement quality.

The initial volatility observed between Weeks 1 and 3 suggests that while the animal possessed a high cognitive understanding of the task (reaching a 92.42% success rate and a high mean compliance score of 3.83 in Week 3), her performance was heavily influenced by the onset of physical discomfort.

This lack of stability culminated in the Week 4 collapse, where both metrics dropped to zero. This sharp decline was a direct consequence of the complete suspension of activities due to physical discomfort rather than a loss or extinction of the trained behavior. This suggests that behavioural compliance remains intact but physically un-executable during acute clinical crises (Wars & Melfi, 2015). Upon the gradual reintroduction of training in Week 5, performance was expectedly low (37.50% success rate; 1.00 compliance score); this was not due to a loss of the trained skill but rather reflected a transitional recovery phase where the animal was still regaining physical stamina.

The subsequent recovery phase offers insights into Camote's behavioural resilience, changing mobility needs, and overall improvement in physical welfare.

The rapid ascent in accuracy during Week 6 (83.67% success rate and 3.67 compliance score) led into a plateau of maximum operational efficiency and behavioural stabilization during Weeks 7 and 8. In this period, compliance stabilized at its peak (4.00) while the success rate exceeded 94%.

Despite spending more time active and moving during these weeks, Camote maintained a good focus, minimizing errors. This high accuracy-to-time ratio indicates that as her physical conditioning improved and her weight gradually decreased, the execution of the target training became significantly easier and more precise, overcoming the initial behavioural inconsistency. In veterinary medicine, gradual weight loss in obese suids is known to alleviate cardiorespiratory strain, potentially enhancing physical stamina and cognitive engagement during operant tasks (Mendl et al., 2010; Yamanashi et al., 2020). This robust behavioural reliability was maintained just before a final decline recorded in Week 9, where compliance fell to 2.75 and the success rate dropped accordingly.

- Syringe

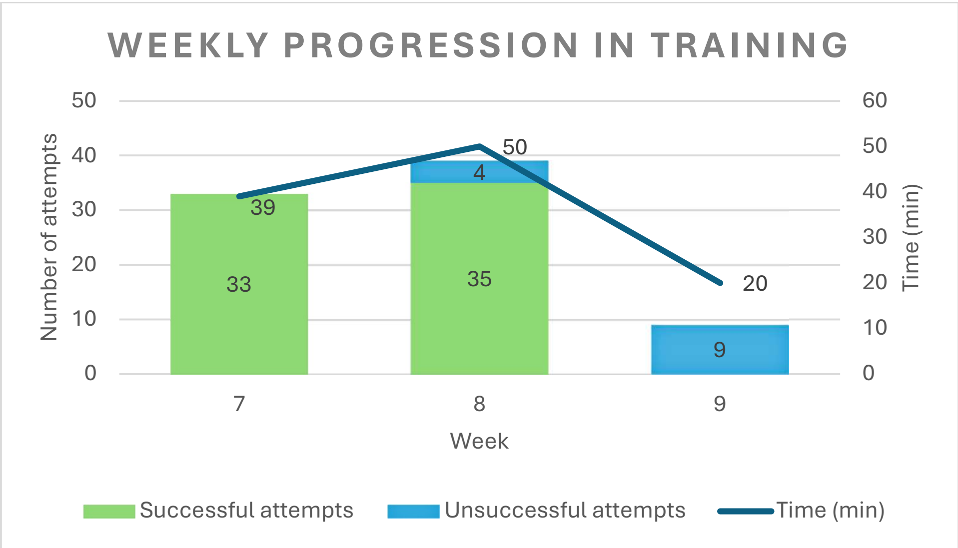

Figure 7.5.4: comparison of weekly time (blue line), successful attempts (green column) and unsuccessful attempts (light blue column) in syringe training. "Attempt" is considered as the action of the trainer of positioning the target, "successful attempt" is defined as the animal touched the target, successfully performing the training aim. The graph shows a shift from complete success of week 7 to all unsuccessful attempts in week 9, with a mixed response in week 8, where the time of contact with the blunt needle was increased.

Camote, as shown by figure 7.5.4, initially demonstrated a rapid, positive response to the injection protocol, maintaining high tolerance and behavioural compliance for the first two weeks (week 7 and 8), including during contact with a blunt needle. However, following an increase in contact pressure and duration, a behavioural threshold was reached.

In subsequent sessions, Camote exhibited a sudden aversion, refusing to tolerate the needle and leaving the training position upon the mere approach of the trainer's hand, even in the absence of the syringe. To mitigate the risk of reinforcing a negative association with the training area, the strategy was adjusted to focus solely on reinforcing the animal for maintaining a stationary position at the training station. It is worth noting that reinforcement for remaining stationary were not considered and computed as formal training trials and consequently are not visible in week 9.

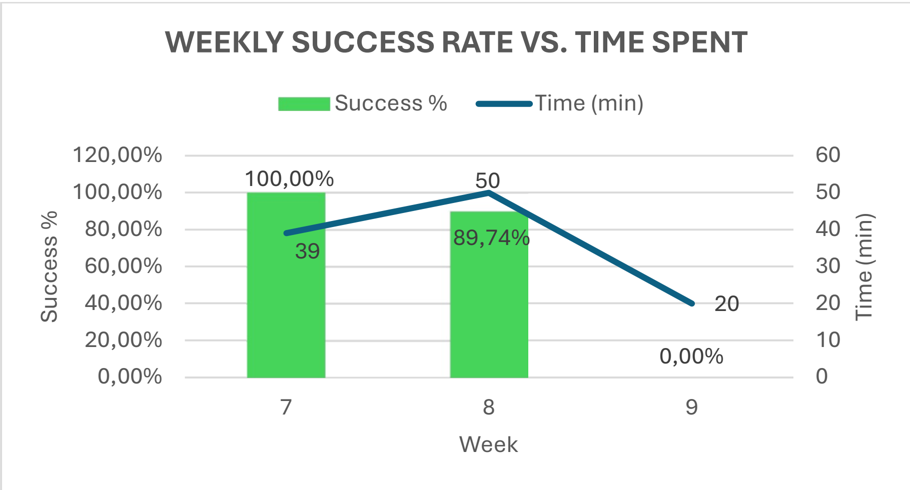

Figure 7.5.5: mean success percentage of syringe training per week. A clear downward trend is visible, which is specular to and confirms the findings in Graph 7.1.4 – 5; a sharp decline is particularly evident through weeks 8 and 9 due to the interruption of the syringe training protocol.

Weekly mean compliance score for syringe training, calculated using the four-tier performance scale, reaches its peak (4) during weeks 7 and 8, before dropping to its minimum (1) in week 9 due to the suspension of proper syringe training.

- Scale

Contrary to expectations, Camote consistently avoided stepping fully onto the scale. Although she occasionally placed one or both forelimbs on the platform, she never positioned her hind limbs, thereby preventing an accurate weight measurement. Despite continuous procedural adjustments and regular repositioning of the equipment over a total of six sessions of varying durations (mean duration 20 min), the outcome remained unchanged. Consequently, the weight-monitoring protocol was discontinued on April 25th, 2026, as the primary limiting factor was identified as a spatial and ergonomic mismatch between the animal's size and the scale size. The scale's surface area was insufficient to allow the animal to comfortably position its entire body, ultimately inhibiting the target behavior.

- Heart

Although the animal demonstrated satisfactory behavioural compliance during the heart rate monitoring training, the clinical interpretation of cardiac auscultation by the veterinary staff was difficult. The consistent presence of muffled heart sounds directly correlated with the patient's diagnosed cardiomegaly and secondary ascites, which altered normal thoracic acoustics. Concurrently, the clinical evaluation was altered by prominent respiratory artifacts; the subject exhibited persistent low-grade respiratory noises and continuous throat gurgling. These acoustic interferences, typical of the advanced pulmonary and vascular congestion secondary to the diagnosed Congestive Heart Failure (CHF) (Cruz et al., 2019), physically masked the thoracic field and precluded a reliable differentiation of potential underlying valvular murmurs. Consequently, the training protocol was discontinued on April 27th.

These premature suspensions represent a known limitation of the study, as it precluded the simultaneous collection of objective clinical data, such as direct heart rate trends and specific recurrent weight measurements, thereby restricting the final analysis primarily to behavioural compliance metrics rather than a comprehensive cardiorespiratory and weight tracking.

8. FOLLOW-UP AND OUTCOME

8.1 Nutritional Outcomes

The outcome of this restriction was positive; the peccaries consumed almost their entire ration at every meal, showing a marked reduction in leftovers compared to both the pre-intervention period.

Although the animals were initially unaccustomed to chickpeas and consistently rejected them, they gradually accepted this source over time. If this selective rejection continues, the sanctuary could consider alternative administration methods, such as blending the chickpeas into a paste and incorporating it directly into the concentrate or offering it separately as a paste.

Furthermore, splitting the concentrate into two separate, water-hydrated bowls provided three major advantages:

1. Volumetric satiety and hydration: wetting the concentrate increased feed volume without adding calories, triggering gastric distension signals that mitigated hunger stress during caloric restriction while ensuring proper hydration (essential particularly for Camote as she’s undertaking diuresis drugs).

2. Mitigation of resource competition: separate feeding stations neutralized hierarchical dominance and resource guarding, preventing hyperphagia in the dominant individual and reducing social stress.
3. Extended ingestion time: the hydrated concentrate prolonged meal duration, acting as a form of occupational enrichment that reduced stereotypic foraging behaviours.

8.2 Training Protocols

Parallel to the dietary intervention, multiple training protocols were implemented with varying degrees of success (Table 8.2.1):

Training	Outcome	Follow-up
Target	Proved to be the most effective and successful strategy implemented in this study. It provided a safe, controlled method to stimulate locomotion within the enclosure without compromising handler or animal safety, while fully respecting the animal's autonomy to terminate the session at any time.	It should be maintained not only as a tool for physical exercise and caloric expenditure but also as a valuable source of daily cognitive enrichment. Continuous mental and physical stimulation is essential to maintain the animal's engagement with its environment and to prevent a relapse into a highly sedentary and lethargic behavioural repertoire.
Syringe	After the adverse response to prolonged needle contact, the focus was redirected toward space desensitization and reinforcing a stationary position at the station, to restart entirely the protocol.	Future attempt must be restarted entirely from baseline to systematically rebuild the animal's confidence. This renewed protocol may limit the number of repetitions per session and utilize high-value, exclusive rewards to prevent behavioural regression and safeguard the animal's voluntary participation.
Stethoscope	The heart rate monitoring training was halted until the body size of the animal permits to correctly evaluate the HR.	Clinical feasibility may improve in the future as the animal loses weight, which could reduce acoustic interference and yield clearer heart sounds. Therefore, the behavior should be maintained through occasional reinforcement sessions, even when diagnostic feedback cannot be fully obtained.
Scale	Camote’s large body size and compromised physical condition prevented comfortable positioning on the weighing platform, making accurate weight measurements impossible through voluntary conditioning.	This implies that alternative, non-invasive welfare indicators (such as visual body condition scoring (BCS) and the monitoring of respiratory rates) must be prioritized over direct scale weighing to assess the animal's physical progression and nutritional status without inducing unnecessary stress.

Table 8.2.1: outcome and relative follow-up of target, syringe, stethoscope and scale trainings.

8.3 Guidelines for Long-Term Management and Continuity

Because this study was designed as a pilot project rather than a definitive solution, operational guidelines are helpful to ensure protocol continuity. To maintain the weight loss trajectory:

- Target training must be continued as the primary method to stimulate voluntary locomotion and maintain behavioural engagement.
- Dietary items should be hidden, and the difficulty of enrichment devices regularly adjusted to maximize physical interaction time and mental stimulation.
- Despite the temporary training suspension, progressive syringe conditioning remains essential for future management to enhance animal welfare during necessary medical interventions, particularly regular sedation for nail trimming.
- Continuous clinical monitoring must be integrated into routine management to assess the subject's long-term health and welfare. To overcome the scale limitations without inducing stress, the animal should be weighed opportunistically during necessary sedation procedures for nail trimming, which are required approximately every three months due to rapid hoof overgrowth. Concurrently, stethoscope training should be maintained through sporadic, low-pressure training sessions; although diagnostic feedback is currently obscured by respiratory artifacts, continuing these attempts will ensure the behavior remains stable until changes in her clinical and physical status allow for clear cardiac auscultation.

9. CONCLUSIONS

9.1 Clinical Interpretation

The patient achieved a total weight loss of 600 grams. Although this outcome did not meet the initial targeted baseline of approximately 2 kg, it represents 1.54% reduction in initial body weight. Given the structural constraints encountered and the animal’s occasional non-cooperative behavior, this preliminary reduction can be considered an acceptable and positive starting point for a long-term weight management protocol. Clinically, this metabolic shift directly seems in relation with a noticeable improvement in the patient’s overall activity and motility. The combined effect of dietary restriction and increased physical exertion is further corroborated by the serum lipid profile. The apparent paradoxical fluctuation in cholesterol levels, specifically, an increase in LDL accompanied by a decrease in HDL, biologically reflects the active mobilization of endogenous fat stores (lipolysis) to meet energy demands during exercise. Although direct measurement of non-esterified fatty acids (NEFA) was not performed, the observed fluctuations in the lipoprotein profile indirectly sustain this lipolytic shift, as consistently reported in literature regarding suiniform metabolic response (Trudeau et al. 2011).

This biochemical evidence suggests that the sedentary, positive-feedback loop observed at the baseline has successfully shifted toward a progressive cycle of structured exercise, nutritional adjustment, physical well-being, and subsequent spontaneous activity (Litten et al., 2010; O'Malley et al., 2013).

Disrupting the patient's behavioural apathy represents one of the most critical achievements of this intervention. This behavioural transition has directly facilitated daily management, as evidenced by faster response times to locomotion cues and increased efficiency during target training sessions.

Ultimately, a more aggressive approach such as sudden, drastic caloric restriction or forced exercise without respecting the animal's voluntary participation, would have likely induced severe negative outcomes. From a physiological standpoint, sudden weight loss in obese patients carries a high risk of hepatic steatosis and metabolic derangement (Browning & Horton, 2004). Behaviourally, a coercive protocol would have triggered distress, leading to a negative association with the target and the handler, thereby compromising the long-term sustainability of the rehabilitation program (Westlund, 2014).

While chronic cardiomegaly and its associated clinical panting cannot be cured, targeted therapeutic management is essential to enhance Camote's quality of life. The ongoing weight loss process is critical, as a reduction in thoracic adipose tissue directly decreases the cardiac workload. Minimizing intrathoracic fat accumulation alleviates the mechanical compression on both the myocardium and the lungs. Consequently, this mitigation of mechanical stress is expected to reduce respiratory distress (panting) and alleviate the secondary effects of ascites, ultimately leading to a significant improvement in the animal's overall physiological well-being.

9.2 Study limitations

Several technical, logistical, and clinical constraints influenced the outcomes of this project. While the initial eleven-week timeframe was originally deemed sufficient, on-site development revealed that a 2 kg weight reduction was unrealistic within this span. Weight loss progression was further hindered by the patient's inconsistent behavioural responses to target training. Since environmental factors (e.g., timing, temperature, and external disturbances) were standardized and controlled, this behavioural variability was directly attributed to the animal's fluctuating health conditions.

The patient's compromised clinical status remained the primary management concern. The cardiorespiratory symptoms directly impaired training compliance, as debilitating panting episodes severely reduced the animal's physical capacity and motivation. For instance, a critical aggravation of these symptoms required a complete suspension of all activities for an entire week. Due to safety constraints preventing direct contact within the enclosure, monitoring relied solely on external observation; nonetheless, consensus among staff and veterinarians confirmed long-term improvements in the animal's overall spontaneous movement and engagement.

Furthermore, strict diagnostics and quantitative monitoring were constrained by the patient's cardiovascular fragility, which made frequent chemical restraint (sedation) too risky. Consequently, tracking cardiac progression relied heavily on non-invasive visual assessments rather than continuous clinical profiling, such as serial echocardiograms. This monitoring deficit was further exacerbated by the logistical impossibility of conditioning Camote to step onto a digital scale voluntarily. The lack of regular, weekly weight data forced the project to rely on less frequent, opportunistic measurements, hindering a precise week-by-week tracking of efficacy.

Dietary management was similarly complicated by social variables. Because the patient shared the enclosure with another peccary with a deeply different attitude and behaviour, absolute control over individual caloric intake was impossible to guarantee. Despite structured feeding protocols, inter-individual competition and the potential for food-stealing meant that the exact quantity of food consumed by Camote could not be isolated or measured with absolute precision.

In addition, structural and space limitations presented some challenges. Although the designated enclosure represented a balanced compromise between management feasibility and animal welfare standards, it inevitably restricted the full behavioural repertoire of a wild peccary, which naturally thrives on extensive foraging and locomotion across diverse forest terrains. For safety reasons and target training practicalities, exercise sessions were restricted to the perimeter of the enclosure, leaving the larger central area underutilized. This restriction made the training routine highly repetitive, potentially reducing the animal's long-term engagement.

Finally, strict safety protocols played a major role in shaping the methodology. Because collared peccaries are potentially dangerous animals capable of jumping, biting, and charging when threatened, direct contact was strictly forbidden, and operators were barred from entering the enclosure while the animal was inside. This necessary lack of direct physical access limited the deployment of more dynamic training techniques and prevented closer clinical monitoring.

9.3 Suggestions

Reflecting retrospectively on the development of this project, several limitations in the initial planning, methodological design, and data management can be identified.

An oversight in the initial design was setting a rigid 2 kg weight loss target within a nine-week timeframe. The physiological complexity of severe obesity, combined with the patient's compromised health, was underestimated, leading to an overly aggressive baseline expectation that did not match the realities of managing a chronic patient. Furthermore, the severity and debilitating nature of the cardiorespiratory symptoms, specifically the panting episodes, were improperly accounted for during the scheduling phase. By failing to integrate clinical contingency buffers into the project timeline, the necessary one-week suspension of training due to a health relapse inevitably impaired the continuity of intervention and data collection.

Initial data tracking would have benefited from an earlier finalization of the data monitoring sheets. Although delaying their full deployment limited early adjustments to the protocol, this gradual approach ultimately allowed the collection system to better adapt to the practical, daily realities of the sanctuary.

Lastly, dietary control and regular weighing presented unexpected practical challenges. Furthermore, without a functional, stress-free system to weigh the animal weekly, collecting continuous weight data to evaluate the diet's progress precisely remained unfeasible.

ACKNOWLEDGMENTS

I would like to thank my supervisor, Prof. Gianfranco Gabai, for his help and invaluable guidance during the fieldwork and the writing process of this thesis. A huge thanks to Claudia, my internship tutor, as well as the veterinarians, the volunteer coordinators, and all the Alturas staff for their support and suggestions throughout my internship. Working with them has been an incredibly rewarding personal and professional experience.

I am deeply, incredibly grateful to my parents for their everlasting emotional support, patience, and for all the opportunities they have given me; everything you have read was only possible thanks to them.

Thank you to Alessandro, my beloved, for helping me through this final year of university and for bringing such fresh breeze into my life. Thanks to Mara, Gianni, and Marco. A special thanks to Barbara for her endless prayers.

Thank you to Federica and Nicole, and to my university friends Virginia, Martina B., Martina M., Elisa, Giulia, and Riccardo: sharing this journey with you was both a pleasure and so much fun. Thanks to Ruby for being such a great friend during our Costa Rica adventure, and beyond.

Finally, thank you to some really special animals: Camote, for being the sweetest potato to ever exist, and Gordon, the best study buddy and the kindest soul I have ever known, you taught me so much without even speaking a word.

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