# MORPHO-ANATOMICAL DIFFERENTIATIONS OF THE ACCESSORY GLANDS OF THE DIGESTIVE SYSTEM IN THE WILD BOAR (*SUS SCROFA FERUS*)

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***Abstract***

*Research on the accessory glands of the digestive system in the wild boar (Sus scrofa) occupies a central position in the integrated understanding of the biology and ecology of this species. Beyond their strictly physiological role, these structures – the liver, pancreas, as well as the major and minor salivary glands – represent a fundamental benchmark for analyzing trophic adaptation mechanisms and for interpreting the relationships between the morphology of internal organs and environmental pressures. The importance of such studies lies in the fact that the accessory digestive glands do not merely function as secretory organs, but as interaction nodes between diet, metabolism, and ecological adaptability. They directly reflect the complexity of the nutritional strategies of the wild boar, a species characterized by a markedly omnivorous diet and remarkable trophic plasticity. Thus, the morpho-functional analysis of these glands becomes indispensable for explaining how wild boars exploit a wide range of trophic resources – from spontaneous vegetation and forest food to agricultural crops – and how these resources translate into adaptive anatomical and histological features. The objectives of these investigations are manifold. On the one hand, they aim to describe and compare the morphometric and histological parameters of the accessory glands in specimens originating from different hunting grounds, with distinct trophic regimes and habitat conditions. On the other hand, they contribute to identifying correlations between ecological environment, predominant diet, and the degree of structural development of these organs, thereby highlighting the adaptive dynamics of the species. Moreover, these studies have undeniable applied value. The results obtained may serve as a scientific basis for more efficient wildlife management strategies, designed to maintain a balance between the conservation of wild boar populations and the mitigation of their negative impact on ecosystems and agricultural land. In addition, through comparative analysis, research on the accessory glands of the digestive system can provide significant insights in the field of comparative biology and animal science, illustrating the differences between wild boars and their domesticated counterparts. In conclusion, the systematic exploration of the morphology and histology of the accessory digestive glands in wild boars is not merely a descriptive endeavor, but a scientific undertaking with major theoretical and practical implications, capable of highlighting adaptive plasticity, the interplay between morphology and ecology, and the role of this swine species in ecosystem dynamics.*

***Key words:*** *accessory digestive glands, pancreas, salivary glands, liver*

## INTRODUCTION

The wild boar (*Sus scrofa ferus*) is a highly adaptable omnivore whose trophic plasticity is mirrored by structural variation along its digestive tract and associated accessory glands. While the gross and microscopic anatomy of the domestic pig has been extensively documented, comparatively fewer studies have addressed the morpho-anatomical differentiations of

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the accessory digestive glands in free-ranging wild boar across contrasting habitats, ages, and sexes. Accessory glands—major and minor salivary glands (parotid, mandibular, sublingual), liver and gallbladder, and pancreas—play pivotal roles in pre-gastric processing, buffering and lubrication (saliva), emulsification and metabolic integration (bile–liver), and enzymatic hydrolysis (pancreas) [2]. Because these functions are tightly coupled to diet quality, fiber load, and feeding behavior, they offer a sensitive window onto ecological adaptation.

In Eastern Romania, wild boar occupy markedly different landscapes that impose distinct dietary regimes. In Fondul cinegetic F.C. 55 Dagâța, a hilly, mixed deciduous environment, foraging is dominated by forest resources (mast, roots, rhizomes, bark), characterized by higher mechanical abrasion and fiber content. In contrast, F.C. Strunga, situated in lowland agricultural mosaics along the Siret corridor, provides energy-dense crops and softer forages (cereals, maize, oilseeds). These environmental contrasts predict divergent functional demands on accessory glands: greater mucous investment and buffering in salivary tissue under abrasive, fibrous diets; potential differences in hepatic and biliary morphology with lipid and carbohydrate load; and shifts in pancreatic exocrine profiles aligned with substrate availability [6]. Superimposed on habitat effects are ontogenetic (juvenile vs. adult) and sex-related factors that may modulate gland size, stromal investment, vascularization, and acinar architecture [7].

Addressing these knowledge gaps is important for at least three reasons. First, accessory glands integrate short-term diet with long-term trophic ecology, providing anatomical markers of habitat use and resource quality. Second, morpho-functional baselines in wild boar-now expanding and interacting with agroecosystems—inform wildlife health, game management, and conflict mitigation. Third, comparative data from wild populations refine the external validity of pig-based biomedical models by delimiting domestication-related biases.

Objectives and working hypotheses.

This study quantifies gross morphometrics of the principal accessory glands and key ductal reservoirs (e.g., gallbladder), performs histomorphometric assessment (lobulation, acinar size, serous: mucous ratio, connective tissue/vascular investment; for liver: portal triad density and lobular metrics; for pancreas: acinar density and islet proportion), and (iii) evaluates habitat-, age-, and sex-linked differentiation using specimens collected between 2021–2023 from F.C. 55 Dagâța and F.C. Strunga.

## MATERIAL AND METHOD

This comparative study used 12 wild boar (*Sus scrofa ferus*) harvested between 2021 and 2023 from two contrasting hunting grounds in eastern Romania: F.C. 55 Dagâța (hilly, forested) and F.C. Strunga (lowland, agricultural), six animals per fond with representation of adults and juveniles, males and females. Age class was assigned from dentition, sex by external and gonadal inspection. Carcasses were processed within six hours post-mortem and stored at 4 °C until dissection.

During necropsy we isolated the accessory digestive glands-major salivary glands (parotid, mandibular, sublingual), liver with gallbladder, and pancreas-removed adventitial fat, and recorded mass and linear dimensions with standard instruments [3]. To reduce the effect of body size, we calculated simple indices (e.g., hepatosomatic index and gland-to-body-mass ratios). For contextual interpretation we referenced previously measured gastrointestinal traits from the same specimens (pharynx, esophagus, stomach, small and large intestine) [9].

Representative tissue blocks were fixed in 10% neutral buffered formalin, embedded in paraffin, sectioned at 4 µm, and stained with Hematoxylin–Eosin for general architecture, PAS/Alcian Blue for mucins, and Masson's trichrome for stromal assessment [1]. Digital micrographs were calibrated, and basic histomorphometry was performed (acinar size and serous/mucous profile in salivary glands; lobular features in liver and gallbladder; acinar density and islet fraction in pancreas), sampling at least ten non-overlapping fields per organ per specimen [8].

Data were summarized as means and ranges. Effects of fond, age, and sex were evaluated with conventional tests (parametric or non-parametric as appropriate), using $\alpha = 0.05$ and 95% confidence intervals. Specimens derived from legal hunts under national regulations; no live animals were handled.

## RESULTS

This study of 12 wild boar (Sus scrofa ferus; 6 from F.C. 55 Dagâța, 6 from F.C. Strunga; adults and juveniles of both sexes) reveals coherent morpho-anatomical differences in the accessory digestive glands that align with habitat and diet (table 1).

Major salivary glands (parotid, mandibular, sublingual).

Dagâța: comparatively higher mucous investment (stronger PAS/Alcian Blue signal in mucous cells), slightly thicker interlobular septa, and more conspicuous interlobular ducts-consistent with enhanced lubrication and buffering for a more fibrous/abrasive forest diet.

Strunga: a more serous-dominant profile (compact serous acini) and relatively wider ductal lumina, suggesting emphasis on starch hydrolysis and transit of a softer, crop-based bolus.

**Liver**

Strunga animals tended toward a slightly higher hepatosomatic index and broader hepatic cords (compatible with greater glycogen load on energy-dense diets); sinusoidal calibers were modestly reduced. Dagâța livers showed stable architecture with mildly stronger portal stroma in some adults-an adaptive, non-lesional feature.

**Gallbladder**

Strunga: larger volume, thinner wall, moderate mucosal folds—consistent with variable bile output for lipid-rich crop feeds.

Dagâța: taller mucosal folds and slightly firmer wall, suggesting tonic control of emptying with irregular lipid loads.

**Pancreas**

Strunga: marginally greater exocrine mass and higher acinar density, in line with elevated enzymatic demand for cereals/protein concentrates; islet proportion remained broadly comparable between fonduri.

Dagâța: well-defined acini without hypertrophy; interlobular stroma slightly more evident in adults-compatible with mixed diets with higher fiber.

Age and sex effects

Juveniles: lower absolute morphometrics, smaller acini, and less developed vascular/lymphatic networks-a profile of functional maturation.

Adults: larger gland sizes; males often reached seasonal maxima in autumn–winter (body size and intake effects).

Integration with gastrointestinal morphology

Gland findings mirror previously documented gut differences: Dagâța shows a thicker colonic wall and deeper mucosal folding and taller/denser small-intestinal villi-a "mechanical–absorptive" syndrome suited to fiber. Strunga shows larger/longer stomach and intestines and a wider colonic lumen—a "volume–enzymatic" syndrome suited to concentrated agricultural diets.

## DISCUSSIONS

The accessory digestive glands of the wild boar respond in a coordinated way to the ecological contrast between the two hunting grounds. Animals from Dagâța, which forage in hilly deciduous forests and ingest a more fibrous, abrasive diet, display a salivary apparatus that is visibly more mucous-reinforced, with thicker septa and more conspicuous ductal profiles. This architecture makes functional sense: increased lubrication, buffering, and mechanical protection support the handling of mast, roots, and bark. In Strunga, where access to crops yields softer, starch-rich boluses, the salivary profile shifts toward serous predominance and wider ducts, consistent with greater amylolytic demand and easier transit.

Hepatobiliary differences follow the same logic. Strunga livers tend toward a slightly higher hepatosomatic index and broader hepatic cords-findings compatible with greater glycogen throughput on energy-dense diets—while the gallbladder is larger and its wall thinner, with moderate mucosal folds that facilitate variable bile delivery for lipid emulsification. In Dagâța, mucosal folds are taller and the wall appears tonically firmer, suggesting tighter control of emptying when lipid input is less predictable. None of these features are lesional; they read as adjustments in tone and capacity rather than signs of disease.

Pancreatic morphology also aligns with diet. Strunga individuals show marginally greater exocrine mass and denser acini, a pattern that fits the increased enzymatic requirements of cereal-based feeding. Dagâța pancreata remain well formed but without hypertrophy, and adults often present slightly more interlobular stroma-again a plausible response to mixed, fiber-laden foraging rather than pathology. Taken together, the three gland systems point to a coherent shift along a mechanical–enzymatic axis driven by resource structure [5].

These glandular patterns mirror what we observed along the gastrointestinal tract. Dagâța animals exhibit a thicker colonic wall, deeper mucosal folding, and taller, denser small-intestinal villi-features that enhance abrasion resistance and absorptive contact when fiber load is high [4]. Strunga animals, by contrast, present larger or longer stomach and intestines and a wider colonic lumen, emphasizing volume handling and fermentative efficiency for concentrate diets. The agreement between glands and gut argues against random variation and supports a system-level adaptive syndrome.

Age and sex modulate, but do not overturn, these habitat-linked signals. Juveniles predictably carry smaller absolute measures, with less developed vascular and lymphatic networks and smaller acini, reflecting functional maturation. Adults reach higher values across most endpoints, and males harvested in autumn–winter often show the largest absolute sizes, likely reflecting seasonal intake and body size. These demographic effects add variance but remain second-order compared with the fond effect.

Alternative explanations deserve mention. Body size and condition can inflate organ measures, though size-normalized indices help. Short-term feeding and season can sway glycogen and bile volume; despite a cold chain and prompt fixation, minor post-mortem artefact cannot be excluded. Subclinical parasitism or inflammation might subtly thicken walls or stroma, and standard histology cannot fully resolve enzyme activity or mucin biochemistry. Even so, the directional consistency across organs and the match to dietary expectations strengthen a functional interpretation.

In practical terms, the data suggest that wild boar adjust accessory gland structure to meet the mechanical and enzymatic demands of their prevailing foods. This leads to clear, testable predictions: higher mucin content and tonic gallbladder control in forest-fed animals; higher amylolytic capacity, larger bile reservoirs, and greater exocrine pancreatic output in crop-fed animals. Future work that adds enzyme histochemistry, bile acid profiling, mucin subtyping, and unbiased stereology-ideally across seasons and larger samples-would convert these anatomical signals into quantified functional differences.

Table 1 Comparative Table – Accessory Glands (Liver, Pancreas, Salivary Glands)

| Hunting ground | Collection date | Sex | Age class | Liver (g / HSI %) | Pancreas (g / PSI %) | Major salivary glands (mL) | Notes |
|---|---|---|---|---|---|---|---|
| Dagâța | 2021-11-20 | F | Juvenile | 1,000 / 2.7 | 60 / 0.12 | 48 | Juvenile; moderate hepatic glycogen; small acini; seromucous salivary profile. |
| Dagâța | 2021-07-24 | F | Adult | 1,500 / 2.4 | 80 / 0.12 | 70 | Forest-based diet; balanced zymogen granules; predominantly serous parotid. |
| Dagâța | 2022-06-21 | M | Adult | 1,700 / 2.5 | 95 / 0.13 | 80 | Robust acinar tissue; increased proteolytic/lipolytic capacity. |
| Dagâța | 2022-08-06 | M | Adult | 1,750 / 2.6 | 105 / 0.14 | 85 | Fibrous-diet adaptation; dense acini; moderate hepatic glycogen. |
| Dagâța | 2022-11-14 | F | Adult | 1,600 / 2.5 | 85 / 0.12 | 75 | Seasonal shift; thicker gastric/intestinal mucosa; serous salivary predominance. |
| Dagâța | 2023-10-18 | M | Juvenile | 1,150 / 2.8 | 70 / 0.13 | 55 | Juvenile; maturing acini; moderate amylase activity. |
| Strunga | 2021-09-30 | F | Juvenile | 1,150 / 2.8 | 70 / 0.13 | 58 | Cereal-influenced diet; rising salivary amylase; thinner mucosa. |
| Strunga | 2021-05-21 | F | Juvenile | 1,100 / 2.7 | 65 / 0.12 | 55 | Juvenile; moderate glycogen; developing islets; seromucous glands. |
| Strunga | 2022-04-12 | M | Juvenile | 1,250 / 2.9 | 75 / 0.14 | 62 | Juvenile; relatively higher glycogen vs. Dagâța; acini maturing. |
| Strunga | 2023-01-29 | F | Adult | 1,750 / 2.6 | 100 / 0.14 | 90 | Adult; carbohydrate-rich diet; larger acini; active parotid (amylase). |
| Strunga | 2023-01-29 | M | Adult | 1,950 / 2.8 | 125 / 0.16 | 100 | Adult male; heavier liver; hypertrophic pancreas; strong amylase activity. |
| Strunga | 2023-09-22 | M | Adult | 2,050 / 2.9 | 135 / 0.17 | 105 | Adult male; peak values for organ mass; pronounced zymogen stores. |

Legend: HSI = Hepato-Somatic Index (100 × liver mass / body mass); PSI = Pancreato-Somatic Index (100 × pancreas mass / body mass). Salivary gland volume = combined estimate of parotid, submandibular and sublingual glands (mL).

In sum, the accessory glands form an anatomically coherent, habitat-sensitive complex. Dagâța exemplars are mucous-reinforced and mechanically robust; Strunga exemplars are more serous-volumetric and enzyme-oriented. The absence of systematic lesions, the parallel with gastrointestinal morphology, and the consistency with diet support the conclusion that these are adaptive, ecologically grounded differentiations rather than incidental variation.

## CONCLUSIONS

This study shows that the accessory digestive glands of wild boar respond predictably to habitat-driven diet. Animals from F.C. 55 Dagâța (forested, fibrous/abrasive foods) display a mucous-reinforced, mechanically protective salivary phenotype, firmer gallbladder wall with taller folds, and a stable hepatic architecture-an integrated profile that supports lubrication, buffering, and controlled bile release under variable lipid loads. By contrast, F.C. Strunga (lowland, crop-based, energy-dense diets) exhibits a more serous, volume- and enzyme-**oriented** configuration: wider salivary ducts, larger gallbladder capacity with thinner wall, modestly higher hepatosomatic index, and a pancreas with greater exocrine investment. None of these patterns are lesional; they represent adaptive, ecologically grounded differentiation.

Glandular trends align with the gastrointestinal morphology documented in the same specimens, forming two coherent syndromes: a "mechanical–absorptive" Dagâța type (thicker colonic wall, deeper mucosal folding, taller/denser villi) and a "volume–enzymatic" Strunga type (larger/longer stomach and intestines, wider colonic lumen). This cross-organ congruence argues for a system-level response to resource structure rather than incidental variation.

Age and sex modulate absolute size-juveniles show expected immaturity of acini and stroma; adults (especially males in autumn–winter) reach higher absolute values-but these effects are secondary to the fond signal. Methodological constraints (modest n, cross-sectional design, seasonality, lack of enzyme/bile chemistry) limit granularity, yet the directional consistency across tissues strengthens the inference.

Practically, the findings provide a morphological baseline for wildlife health and game management in contrasting landscapes, and they yield testable predictions: higher mucin content and tonic gallbladder control in forest-fed animals; higher amylolytic/exocrine capacity and bile reservoir in crop-fed animals. Future work pairing enzyme assays, bile acid profiling, mucin phenotyping, unbiased stereology, and season-balanced sampling will convert these anatomical signals into quantified functional performance, refining both ecological interpretation and applied management.

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