Italian Journal of Food Safety

https://www.pagepressjournals.org/index.php/ijfs/index

eISSN 2239-7132

Please cite this article as:

Peruzy MF, Smaldone G, Gammarano N, et al. **Analysis of *post-mortem* inspection outcomes in water buffalo (*Bubalus bubalis*) slaughtered in the province of Caserta (Campania region, southern Italy)**. *Ital J Food Saf* doi:10.4081/ijfs.2024.12744

Submitted: 24-06-2024
Accepted: 05-11-2024

Analysis of *post-mortem* inspection outcomes in water buffalo (*Bubalus bubalis*) slaughtered in the province of Caserta (Campania region, southern Italy)

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Key words: water buffalo, post-mortem inspection, lesions.

Contributions: all the authors made a substantial intellectual contribution, read and approved the final version of the manuscript, and agreed to be accountable for all aspects of the work.

Conflict of interest: the authors declare no potential conflict of interest.

Ethics approval and consent to participate: not applicable.

Funding: none.

Availability of data and materials: data and materials are available from the corresponding author upon request.

Abstract
To date, data on *post-mortem* inspection outcomes in water buffaloes are absent. The present study aimed to analyze the prevalence of lesions recorded in buffaloes slaughtered from 2018 to 2022 in the province of Caserta by analyzing the data extracted from the Management Information System for Food Safety and Veterinary Public Health (GISA Campania). Between 2018 and 2022, 185,583 buffaloes were slaughtered, with a growing trend from 2018 (n=29,705) to 2022 (n=47,366). A total of 3985 lesions were recorded. At least one lesion was found in 2846 animals (1.53%). The area most frequently affected by lesions was the reproductive system (n=1046/3985; 26.24%) followed by the udder (n=929/3985; 23.31%), liver (n=511/3985; 12.82%), lungs (n=386/3985; 9.69%) and musculoskeletal system (n=192/3985; 4.82%). Degeneration was the most commonly observed condition in the liver (n=387/511; 75.73%), while pneumonia and pleuritis were frequently reported in the lungs (n=197/386; 51.04%). Additionally, traumatic injuries to the musculoskeletal system were also prevalent (n=152/192; 79.17%), while pericarditis and myocarditis were commonly found in the heart (n=64/102; 62.74%). During the period analyzed, a tuberculous-related lesion was found in 186 animals (15.41%), with a decreasing trend observed over the years. The number of lesions observed in this study is relatively low and has been decreasing over the years. This decline may be related to the adoption of stricter biosecurity measures for controlling infectious diseases and the modernization of livestock practices toward precision farming. This study demonstrates how the slaughterhouse can be an important epidemiological tool. Incorporating increasingly specific data at the slaughterhouse provides epidemiological information that can be used to understand disease trends and causes.

Introduction
Water buffalos (*Bubalus bubalis*) were originally domesticated in South Asia. Today, while they are still mainly concentrated in Asia, herds can also be found in Europe and South America (Lorenzo *et al*., 2019). Italy, with 403,093 animals, is the leading European country for buffalo breeding (Tamburrano *et al*., 2019), mainly concentrated in farms located in the Campania region (Southern Italy) and in the province of Caserta (Di Stasio *et al*., 2021; Ottaiano *et al*., 2024). Buffaloes are predominantly raised for milk and dairy products while meat is usually considered a secondary product derived from males or females at the end of their production cycle. The meat is mostly consumed in areas where buffalo breeding is traditionally present and is marketed as fresh-cut meat and gastronomy products (salami, bresaola, *etc*.) (Borghese, 2022). Although the consumption of buffalo meat is still low compared to beef, it has increased in recent years due to its peculiar nutritional characteristics, such as low fat and cholesterol content (Di Stasio *et al*., 2021). Moreover, compared with bovine, buffalo meat is richer in proteins and micronutrients, such as iron, zinc, and vitamins (Landi *et al*., 2016; Tamburrano et al. 2019b).
According to the EC Regulation 853/2004 (European Parliament and Council of the European Union, 2004), *Bubalus bubalis* is a domestic ungulate and undergoes *post-mortem* inspection to verify compliance with requirements on human and animal health, and animal welfare (European Commission, 2019a - Art. 18 and 19 Reg. 627/2019). *Post-mortem* inspection in buffaloes is mainly visual; however, palpation and incision are necessary to detect tuberculosis and *Taenia saginata* (tapeworm) cysticercosis (European Commission, 2019a - Reg. 627/2019). According to Reg. 624/2019 in Europe (European Commission, 2019b), *post-mortem* may be performed by an Official Veterinarian (OV) or, in specific conditions, by an Official Auxiliary under the responsibility of the OV. In the Campania region (Southern Italy), *post-mortem* findings by the OV are recorded through General Monitoring Directors (Di.Ge.Mon) of the Management Information System for Food Safety and Veterinary Public Health (GISA Campania). GISA Campania is an IT system that manages integrated services and activities in the Campania region. GISA is an informational computer system available only to OV and it is used to plan, program, manage, and evaluate activities and performances related to official controls. Since the prevalence of macroscopic lesions on carcasses and offal of

water buffalo is still unknown, the present study aimed to estimate the prevalence of the anatomopathological lesions of water buffalo reported by the OV in the province of Caserta (Campania region) between 2018 and 2022, by analyzing the data extracted from GISA Campania.

Materials and Methods

Data were obtained from the system Di.Ge.Mon of the GISA Campania. Data were extracted from the data extrapolation section according to the following research and aggregation criteria: animal species (buffalo), reference period (2018-2022), reference province (Caserta), place and date of slaughter, and anatomopathological lesions found by the OV.

Statistical analysis

The differences between the occurrence of the lesions were assessed with a chi-square test. A probability value of less than 0.05 ($p<0.05$) was defined as statistically significant.

Results

Between 2018 and 2022, a total of 185,583 buffaloes were slaughtered in the Caserta province. The lowest number of animals was slaughtered in 2018 (n=29,705), while the highest was recorded in 2022 (n=47,366). The buffaloes originated from 29 different farms in Italy; however, most of them were from the province of Caserta (n=164,958, 88.89%). During the years under investigation (2018-2022) a total of 3985 lesions were recorded by the OV. The lowest percentage of lesions was observed in 2021 (n=538, 1.46%) while the highest was in 2018 (n=1141, 3.8%).

Of the total number of animals slaughtered, 2846 had at least one lesion (1.53%) (Figure 1). By years, 981 animals (3.8%) had at least one lesion in 2018, 434 (1.25%) in 2019, 558 (1.5%) in 220, 327 (1.46%) in 2021 and 546 (1.78 %) in 2022.

The area most frequently affected by lesions was the reproductive system (n=1046/3985, 26.24%; n=1046/185,583, 0.56%) followed by the udder (n=929/3985, 23.31%, n=929/185,583, 0.49%). For 592 animals (14.85%), lesions were recorded at the viscera level, but no further information was provided. The organs least affected by lesions were sub-iliac lymph nodes (n=1/3985, 0.025%, n=1/185,583, 0.00053%), stomach/ prestomachs (n=1/3985, 0.025%, n=1/185,583, 0.00053%), and spleen (n=1/3985, 0.025%, n=1/185,583, 0.00053%) (Table 1). In 1888 cases, no information related to the lesion recorded was provided.

The only lesions recorded on the genital system were metritis/endometritis (n=103, 9.85%) because, for 943 animals, no further information was provided.

Mastitis (n=33, 3.55%), followed by tuberculous lesions (n=10, 1.08%) was frequently recorded on the udder; however, for 886 animals no further information was provided.

Degeneration was the most frequently reported finding (n=387, 75.73%) on the liver while in lungs, pneumonia and pleuritis (n=197, 51.04%) were commonly reported.

Traumatic injuries in the musculoskeletal system were also frequently reported (n=152, 79.17%) while pericarditis/myocarditis (n=64, 62.74%) were frequently reported on the heart.

Echinococcosis affected a total of 106 buffaloes, corresponding to 0.06% of the total. Hydatid cysts were recorded in the lungs and liver of 52 (49.06%) and the liver of 29 (27.36%) animals, respectively. Moreover, in 25 animals (23.58%) these were found in both organs.

Tuberculous lesions were found in 186 animals (0.10%), mainly in the tracheobronchial lymph nodes (n=70, 37.63%), retropharyngeal lymph nodes (n=65, 34.95%), lungs (n=56, 19.79%) and mediastinal lymph nodes (n=48, 16.96%). The most frequently encountered lesions were from the primary complex.

A decreasing trend related to the tuberculous lesions from 2018 (n=65, 0.22%) to 2022 (n=9, 0.02%) was observed (Figure 2).

Discussion

During the 5 years under investigation, a total of 185,583 buffaloes were slaughtered in the Caserta province. To our knowledge, this is the first study that provides a comprehensive overview of *post-mortem* inspection outcomes in water buffaloes. The province of Caserta was chosen for this investigation due to the higher number of buffaloes raised and slaughtered in the province compared to other locations. In 2022, according to ISTAT, 42.37% of the buffaloes raised in Italy were slaughtered in this province.

In the present study, research on cattle was used to make comparisons. Of the total number of animals slaughtered, 2846 had at least one lesion (1.53%). A higher number of lesions were reported in the study by Tembo and Nonga (2015) (29.40%) in Tanzania, Ceccarelli *et al*. (2018) (14.13%) in Italy, and Ciui *et al*. (2023) (13.26%) in Bavaria. The lower number of lesions detected in Buffaloes compared to cattle may arise from the fact that buffaloes are more resistant to diseases (Srirattana, 2022).

In the present study, the reproductive system, udder, liver, lungs, and musculoskeletal system were the areas with the highest number of lesions detected.

In the study by Ceccarelli *et al*. (2018) on cattle slaughtered, percentages were calculated based on the total number of lesions. Ceccarelli *et al*. (2018) found that the lung was the organ most frequently affected by lesions (64.86%), which is higher compared to the rate observed in our study (9.68%). Additionally, Ceccarelli *et al.* (2018) reported a higher percentage of lesions in the lung (31.2%) compared to our study (9.68%). The stomach was frequently affected in Ceccarelli *et al.*'s study (11.63%), a percentage that differs from that observed in the present study, where the rate of lesions in this organ is among the lowest (0.025%). Similarly, both studies indicate that the spleen is rarely affected by lesions (0.01% in Ceccarelli's study and 0.025% in ours).

In the study by Ciui *et al.* (2023) conducted on cattle slaughtered in Germany, the percentages were calculated based on the total number of animals slaughtered. In the aforementioned study, the liver was the most commonly affected organ, accounting for 12.28% (n=18,630), which differs from the percentage in the present study (n=511, 0.27%). In the study of Ciui *et al*. (2023), the prevalence of lung lesions was 7.56% (n=11,477), slightly higher than the rate observed in the present research (n=386, 0.20%). The heart exhibited a frequency of lesions of 1.89% (n=2862), higher than that which was observed in buffaloes in the present study (n=102, 0.05%). In contrast to the present work in which the kidney was rarely affected by lesions (n=1, 0.0005%), Ciui *et al*. (2023) report a 20.27% (n=41) prevalence of kidney lesions.

In the study of Tembo and Nonga (2015) conducted on cattle slaughtered in a Tanzanian slaughterhouse, the percentages were calculated based on the total number of animals slaughtered. The lung was the organ most frequently exhibiting lesions (n=9015, 10.5%), a higher rate compared to that observed in the present research (n=386, 0.20%). This was followed by the intestine (n=6276, 7.2%), liver (n=5402, 6.3%) and kidney (n=3291, 13%). These values are higher than those found in buffaloes in the present study (liver n=511, 0.27%, other genitourinary organs n=1, 0.00053%). In line with the findings of the present work, lesions on the spleen were not frequently reported (0.8% in cattle and 0.00053% in buffalo) in the study by Tembo and Nonga (2015).

In a study by Edo *et al.* (2014) at the Adama slaughterhouse in central Ethiopia on cattle slaughtered, the percentages were calculated based on the total number of animals slaughtered. Liver lesions were the most prevalent (n=944, 25.7%). This was higher than those observed in the present study (n=511, 0.27%). Additionally, in the study by Edo *et al*. (2014) a higher percentage of lesions was observed on the lung (n=911, 24.8%), heart (n=116, 3.1%), and kidney (n=17, 0.5%).

Numerous studies have been conducted on the genital tract of water buffalo given its biological and economic importance. In the study conducted by Saxena *et al.* (2016) in Rajasthan (India), 266 out of 760 buffaloes (35%), presented anomalies of the genital tract, and in the study conducted by Bhadaniya *et al.* (2019) in a local slaughterhouse in Junagadh (Gujarat), 44 out 110 slaughtered buffaloes (40%) presented with genital tract pathologies. These percentages are higher than our

study's (n=1046, 0.56%). In the study by Saxena *et al.* (2016), the prevalence of inflammatory pathologies (metritis and endometritis) was 16.09%, a higher figure compared to the 9.85% observed in the present work.

Regarding the udder, in a study by Restucci *et al.* (2019) carried out on 50 buffalo udders, 2 (4%) showed lesions attributable to mastitis. This value is similar to the findings in our study (mastitis n=33, 3.55%)

Degeneration was the most frequently reported finding (n=387, 75.73 %) on the liver while in the lungs, pneumonia/pleuritis (n=197, 51.04 %) were commonly reported. Regarding the liver, in the study by Ciui *et al.* (2023), degeneration was the primary cause of liver condemnation (69.7%), a value that closely aligns with the findings of the present study. In other studies, parasitic infestations were the leading cause of liver sequestration. In the study by Ceccarelli *et al*. (2018) on slaughtered cattle, distomatosis was the most common cause of liver sequestration (n=1090, 23.7%), followed by liver abscesses (n=1067, 23.2%). Similarly, in the study by Edo *et al.* (2014) in Ethiopia, parasitic infections were among the most frequent causes of sequestration: dystomatosis was the most common lesion found in the liver (37.5%), followed by hydatidosis (25.1%). According to Tembo and Nonga's study (2015), fasciolosis was the most frequent cause of liver sequestration (72.2%). In the present study parasites on/in the liver were reported in 65 water buffalo (Echinococcus = 54, dystomatosis = 9), but in two cases, information related to the organism was not reported (Table 1).

Regarding the lungs, the results are consistent with those reported by Peruzy *et al*. (2024), where pleuritis was one of the most frequent lung injuries (56.67%), and by Ceccarelli *et al.* (2018), who reported a 51.20% prevalence of pleuritis.

Circulatory disorders (congestion, edema, emphysema, hemorrhages, pleuritis, *etc*.) were identified as the most common lesion on the lung (n=4661, 40.6 %), in a study conducted in Germany (Ciui *et al.* 2023).

In the present study, echinococcosis was reported in 77 water buffaloes. Hydatid cysts in the lungs were one of the most common lesions detected in the study by Tembo and Nonga (2015, 27.3%) in Tanzania and by Edo *et al*. (2014, 86.6%) in Ethiopia.

In the present study, traumatic injuries to the osteomuscular parts were frequently reported (n=152, 10.18%). These lesions, associated with trauma, suggest a disregard for animal welfare during transportation (Council of the European Union, 2005) and slaughter (Council of the European Union, 2009).

Lesions related to tuberculosis, echinococcosis, and brucellosis were reported in the present research albeit at a low prevalence (tuberculosis = 0.10%, echinococcosis = 0.06%, and brucellosis = 0.01%). These being listed as zoonoses and zoonotic agents, are subject to surveillance as per Annex I of Directive 2003/99/EC of the European Parliament and Council of the European Union (1999).

A higher prevalence of tuberculosis lesions was reported in Sicily during two different 3-year periods (2010-2012; 2017-2019) by Abbate *et al.* (2020, 5.21 %) and in Turkey by Yibar *et al.* (2015, 1.32%). Interestingly in the present study, a decreasing trend related to the tuberculous lesions from 0.22% in 2018 to 0.02% in 2022 was observed (Figure 2).

Regarding the anatomical localization of lesions, in the study by Abbate *et al.* (2020) 5173 (90.08%) out of 5221 positive cattle exhibited gross lesions in the thoracic cavity (lungs and/or lymph nodes), while 0.77% (n=40) and 0.15% (n=8) of the positive animals displayed hepatic (liver and/or portal lymph nodes) and generalized distribution of lesions respectively. These findings are in agreement with those reported in the present study in which, tuberculosis related lesions were most frequently reported in the tracheobronchial (n=70, 37.63%) and retropharyngeal (n=65, 34.95%) lymph nodes and the lungs (n=65, 34.95%).

Regarding echinococcosis, a higher prevalence was reported by Mathewos *et al.* (2022) (17.9%) who detected a total of 321 cysts from various organs, with a prevalence of 48.3%, 33.3%, 15.6%, and 2.8% from the lungs, liver, kidneys, and spleen, respectively. In line with the results of Mathewos *et*

al. (2022), in the present study, out of 106 positive animals, echinococcal cysts were predominantly found in the lung and liver (lung = 49 %; liver = 27.35 %; both organs =23.58%).

Conclusions

This study underscores the importance of *post-mortem* examination findings in buffalo species, which had not been previously analyzed. Despite being a minority species compared to other bovines slaughtered in Italy, buffaloes constitute a substantial portion of animals slaughtered in the province of Caserta and play a crucial role in the local economy. Additionally, there is a steady rise in consumer demand for buffalo meat. The rate of lesions reported on organs was low and has further decreased over time, indicating a positive trend that may be linked to improvements in the implementation of biosecurity measures. Analyzing specific biosecurity protocols in place during the study period and correlating these with lesion prevalence data could help inform future practices. The organs most frequently showing lesions were the reproductive system and the udder, likely related to the primary purpose for which buffaloes are raised in Campania: the production of milk, a crucial raw material for key dairy products produced and consumed in the region. Moreover, lesions associated with zoonotic pathologies were found to be uncommon. This is a positive finding, especially for this region, where tuberculosis and brucellosis have not yet been eradicated. The collection and analysis of lesion data at the slaughterhouse are integral to the reinforcement of efforts toward preventing, controlling, and promptly identifying the emergence of animal diseases and/or diseases transmissible to humans. However, the study is limited to the province of Caserta. Expanding the research to other provinces or regions may provide a more comprehensive understanding of *post-mortem* outcomes in water buffaloes.

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Table 1. Number of lesions recorded in different anatomic areas of buffaloes.

Anatomic area	**n.**	**Anatomic area**	**n.**
Genital system	1046	Heart	102
Metritis/endometritis	103	Pericarditis/myocarditis	64
Other	943	Degeneration	38
Udder	929	Tracheobronchial lymph nodes	70
Mastitis	33	Tubercolosis	70
Tubercolosis	10	Retropharyngeal lymph nodes	65
Other	886	Tubercolosis	65
Corata*	592	Mediastinal lymph nodes	48
Liver	511	Tubercolosis	48
Other parasites	2	Pregnant uterus	17
Cirrhosis/hepatic sclerosis	21	Brucellosis	17
Degeneration	387	Seminal vesicles and testes	12
Distomatosis	9	Hepatic-mesenteric lymph nodes	5
Echinococcus	54	Tubercolosis	5
Hepatitis	19	Mandibular lymph nodes	4
Tubercolosis	8	Tubercolosis	4
Other	11	Viscera of the thoracic cavity	2
Lungs	386	Tubercolosis	1
Echinococcus	77	Other	1
Pneumonia/pleurisy	197	Sub-Iliac lymph nodes	1
Tubercolosis	65	Tubercolosis	1
Other	47	Stomach/prestomachs	1
Osteomuscular parts	192	Inflammations/runiminitis	1
Actinomycosis/actinobacillosis	1	Other genitourinary organs	1
Abscess/phlegmon	31	Brucellosis	1
Degeneration	2	Spleen	1
Trauma injuries	152		
Tubercolosis	6		

*Set of lungs heart liver trachea esophagus diaphragm and spleen.

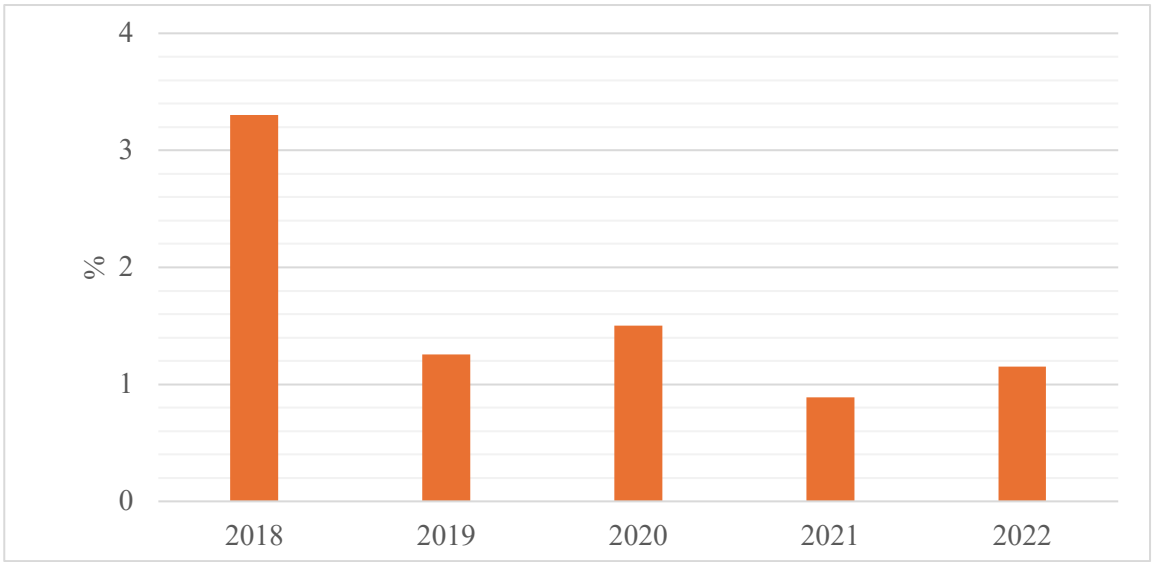

Figure 1. Percentage of slaughtered water buffalo with ≥1 lesion recorded.

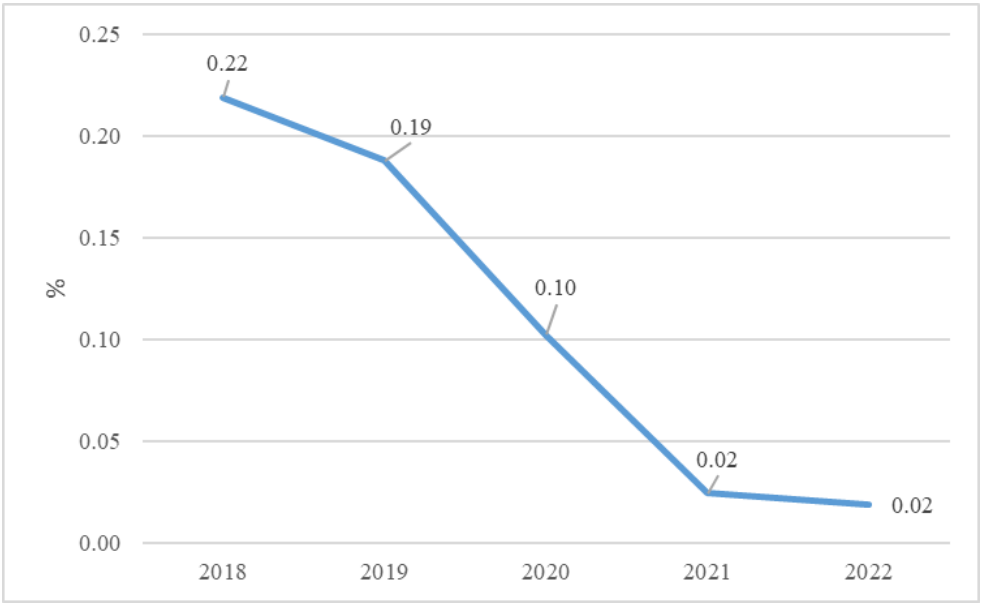

Figure 2. Percentage of tuberculous lesions recorded in buffaloes between 2018 and 2022.