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Big data analysis descriptively of *Brucella abortus* cases in Indonesia during 2006-2020

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Abstract

Brucellosis represents a formidable zoonotic challenge, primarily impacting animal breeders and raising substantial health and economic concerns. This study delves into the epidemiological analysis of *Brucella abortus* infections in Indonesia, leveraging the extensive quantitative big data from the World Animal Health Information System (WAHIS) database managed by the World Organisation for Animal Health (WOAH). Covering the period from 2006 to 2020, the research utilizes advanced clustering techniques to dissect the incidence and distribution of this zoonotic disease across various Indonesian provinces and animal species, including cattle, buffaloes, sheep, goats, and swine. The findings reveal a prominent prevalence of the infection in Sulawesi Selatan Province, accounting for 26.71% of cases, with a fluctuating trend observed nationwide and the peak incidence in 2019, notably in Sulawesi Tenggara Province. The study highlights cattle as the species most susceptible to *Brucella abortus*. The comprehensive analysis underscores the criticality of targeted interventions and sustained surveillance in particular regions, especially focusing on cattle. This research not only enhances understanding of Brucellosis's spread and impact in Indonesia but also aids in formulating effective disease management strategies, thereby addressing both health and economic concerns associated with this zoonotic challenge.

Keywords: Animal species; Big data; *Brucella abortus*; Indonesia province; WAHIS

1. Introduction

The incidence of Brucellosis in animals in Indonesia is a significant concern due to its zoonotic nature and potential economic impact. The prevalence of Brucellosis in livestock, particularly in ruminants, is a cause for concern in many regions, including South Asia and Africa (1). Factors such as increased animal feeding, lack of immunization, and frequent trading have been implicated as key risk factors for the dramatic increase in brucellosis incidence in the past decade (2). Livestock centers in Indonesia have reported a high prevalence of Brucellosis, reaching 40% and spreading almost throughout the country (3). This high prevalence is a cause for concern, as it poses a significant risk to both animal and human health.

Brucella abortus is a significant pathogen within the genus Brucella, known for causing Brucellosis primarily in cattle. The genus Brucella consists of several recognized species, each with distinct pathogenicity and host preferences, including *Brucella abortus* (cattle), *Brucella canis* (dogs), *Brucella melitensis* (goats or sheep), *Brucella suis* (swine),

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Brucella ovis (rams), and *Brucella neotomae* (desert rats) (4). The zoonotic nature of *Brucella abortus* is a cause for concern, as it can be transmitted to humans, leading to Brucellosis. The disease manifests as abortion, sterility, and lameness in animals and can be transmitted to humans through various means, such as inhalation of aerosolized bacteria, ingestion of contaminated tissues, or contact with infected animals (5).

Epidemiological investigations have revealed the significance of Brucellosis in various host species, including cattle, goats, camels, and wildlife, highlighting the broad spectrum of its impact (6–9). Furthermore, the zoonotic potential of Brucellosis underscores the importance of understanding its epidemiology in both animal and human populations (10–12). The interconnectedness of brucellosis epidemiology between animals and humans emphasizes the need for a holistic One Health approach to disease control and surveillance (13,14)

Moreover, the identification of risk factors associated with brucellosis transmission, such as farm location, breed of dairy cattle, and abortion history, provides valuable insights for targeted intervention and control measures (15,16). Additionally, the role of wildlife and the environment in the epidemiology of Brucellosis has been recognized, necessitating a comprehensive understanding of the ecological factors influencing disease transmission (17,18).

The World Organisation for Animal Health (WOAH), formerly called OIE, plays a crucial role in the global notification and monitoring of animal diseases. OIE's World Animal Health Information System (WAHIS) serves as a key platform for the notification of animal diseases, including those in wildlife (19). OIE's global legal framework enables it to request, collect, and share animal health information among its member countries, facilitating early warning and response to disease outbreaks (20,21). The sensitivity of the international notification system for wildlife diseases, as demonstrated by the OIE-WAHIS data on tularemia, underscores the importance of surveillance and notification systems in disease management (22). OIE's international standards and guidelines contribute to the safe trade of animals and animal products, aiding in the prevention of disease spread (23,24). Additionally, implementing OIE international standards presents

This study seeks to bridge a significant research gap by providing an in-depth analysis of the substantial yet unexplored big data on *Brucella abortus* infections in Indonesia, extracted from the WAHIS database. The focus is on a retrospective examination of infection cases spanning from 2006 to 2020. This comprehensive analysis aims to elucidate the epidemiological landscape of Brucellosis in Indonesia, offering a detailed portrait of the disease's incidence over the aforementioned period. The insights derived from this study are poised to confer substantial benefits to stakeholders involved in the management, prevention, and mitigation of Brucellosis outbreaks in Indonesia. By equipping these entities with a robust understanding of the disease's dynamics, the study aims to facilitate more informed, strategic decision-making processes, thereby enhancing the effectiveness of future interventions aimed at controlling this zoonotic challenge.

2. Methodology

2.1. Data mining

Data mining the incidence of *Brucella abortus* infection cases in Indonesia from 2006 to 2020 were meticulously extracted from the WAHIS database. This extraction was conducted through the 'Quantitative Data' section, accessible via the link: https://wahis.woah.org/#/dashboards/qd-dashboard. The aforementioned dataset is open-source, readily available to the global community and academic researchers. Explicit permission for the utilization of this data has been permitted by the International Organization for Animal Health (OIE/WOAH). There were pertinent to note certain limitations inherent to the 'Quantitative Data' feature of the WAHIS database in the context of research applications:

- Region : ASIAN
- Country: Indonesia
- Disease: *Brucella abortus* (Inf. with)

Then, we have to choose menu Export Data to obtained data in Excel format as raw material for this study (Figure 1)

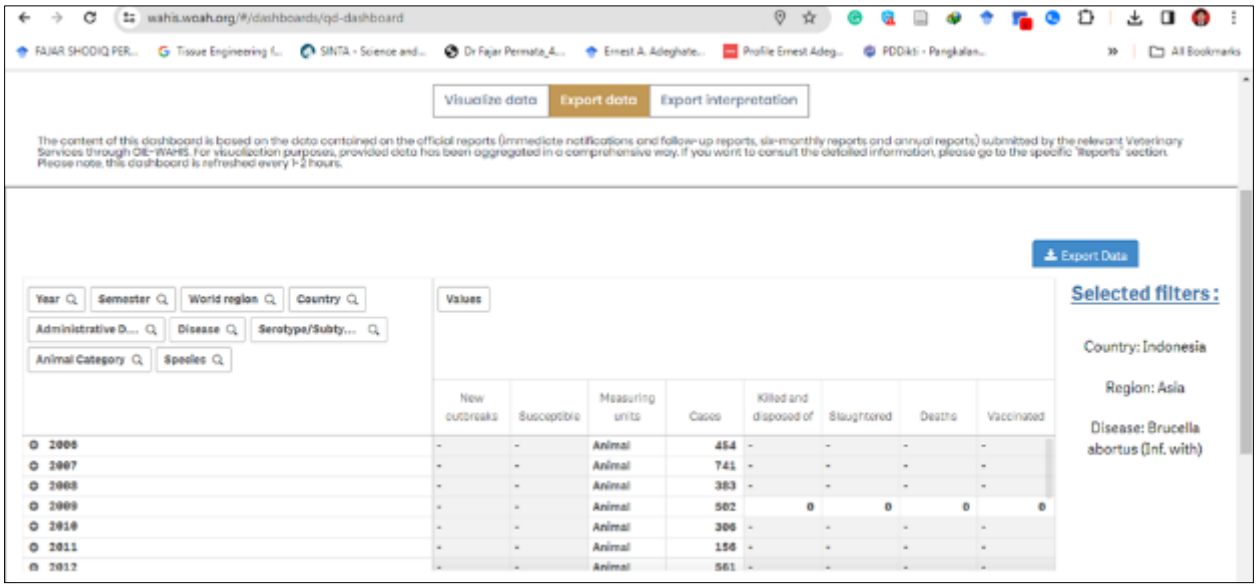

Figure 1 The collation of data pertaining to *Brucella abortus* infection cases in Indonesia, spanning the timeframe from 2006 to 2020, was meticulously sourced from the WAHIS website, an online portal administered by the World Organisation for Animal Health (WOAH)

2.2. Data analysis

The extensive dataset pertaining to *Brucella abortus* infections, sourced from the WAHIS database, was methodically processed utilizing clustering techniques. This analysis was structured based on the geographical delineations of Indonesian provinces and the categorization of affected animal species, implemented through meticulous tabulation. Trends within the dataset were closely observed on an annual basis over the period extending from 2006 to 2020, with the aid of graphical representations. The data visualization was adeptly executed using line graphs and pie charts, facilitated by the application of SPSS software, version 25. Subsequently, the dataset underwent a comprehensive descriptive analysis.

3. Results

The findings from the research indicate that the incidence of *Brucella abortus* infection in Indonesia, spanning from 2006 to 2011, remained relatively low, with case counts varying between 156 and 741. However, there has been a discernible upward trend in the number of cases, culminating in a peak in 2019 with as many as 2,364 instances. This surge was followed by a dramatic decline in 2020, where the case count plummeted to a mere 196, as depicted in Figure 2. The cumulative incidence of *Brucella abortus* infection in Indonesia, over the period spanning from 2006 to 2020, amounted to a total of 11,709 cases.

This research further elucidates that, within the time frame of 2006-2020, the province of Sulawesi Selatan in Indonesia exhibited the highest incidence of Brucellosis, accounting for 3,128 cases, which represents approximately 26.71% of the total cases (referenced in Table 1 and Figure 3). It is noteworthy to mention that within the WAHIS database, the data for Indonesia provinces were collected as Indonesia (*) (as shown in Table 1, Figures 3 and 4). This aggregation was attributable to specific intervals (January 2010 – June 2011; July-December 2013 and 2016), during which the reported data were not disaggregated by province. Analyzing the trajectory of cases across various provinces in Indonesia reveals a highly erratic pattern in the incidence of Brucellosis between 2006 and 2020. This pattern was characterized by fluctuations (Figure 4), with periodic rises and falls, as well as sporadic occurrences, since the manifestation of Brucellosis cases is not consistent across the years. But, Sulawesi Tenggara has the highest incidence of Brucellosis in 2019 as 1,221 reported cases (Table 1 and Figure 4).

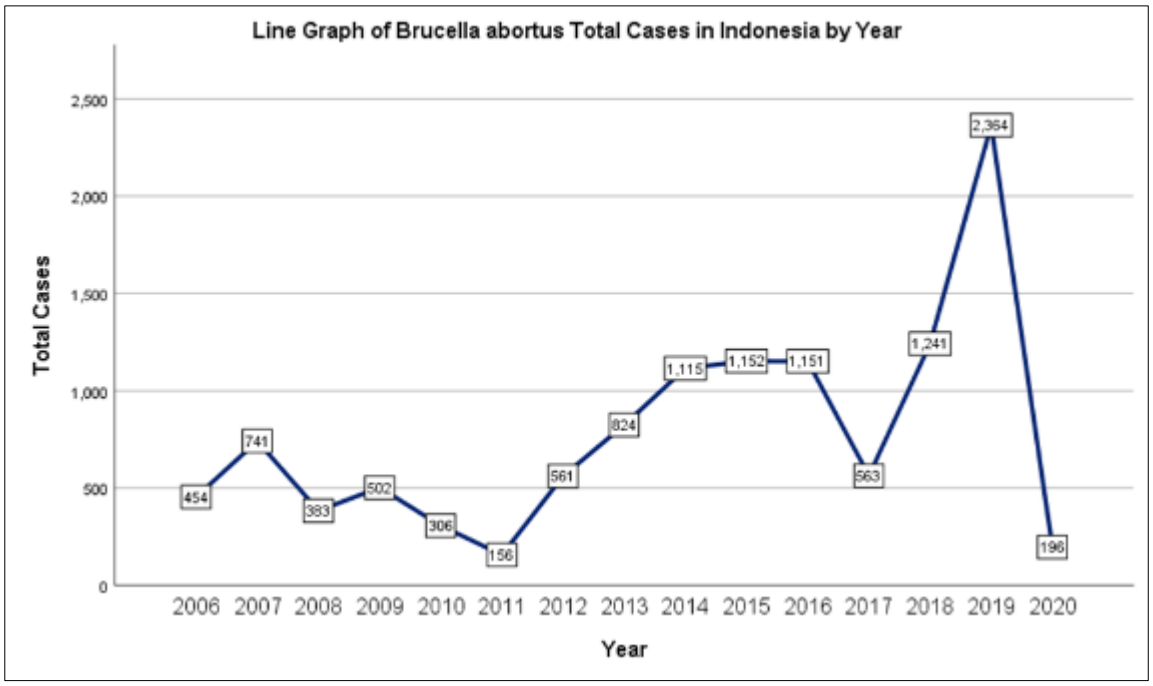

Figure 2 Line graph of *Brucella abortus* infection number cases in Indonesia during 2006-2020

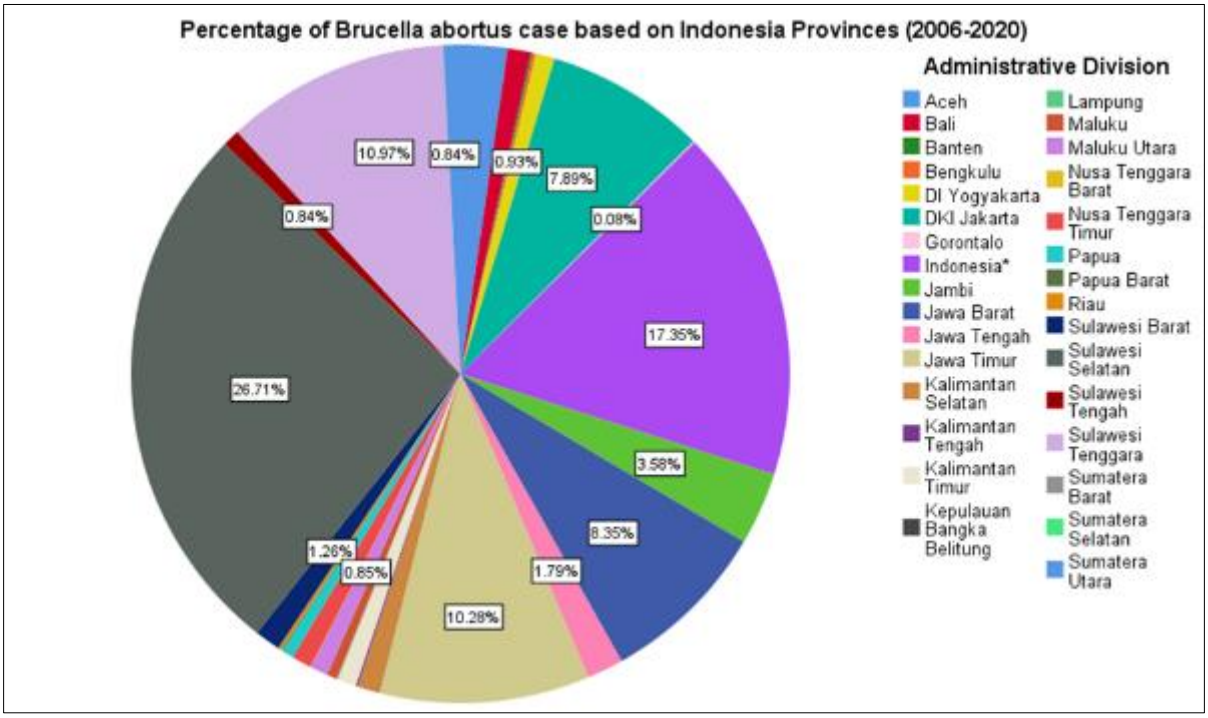

Figure 3 A pie chart delineating the proportionate distribution of *Brucella abortus* cases across various provinces in Indonesia during the period of 2006-2020. The preeminent share of these cases, constituting 26.71%, is attributed to the Sulawesi Selatan Province. It is important to note that instances where data are collectively represented under the term "Indonesia (*)" arise from specific periods of data aggregation

Table 1 Clustering data of *Brucella abortus* infection cases based on Indonesia provinces during 2006-2020

Indonesia Province	**Year**															
	2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2006-2020**
	Cases	**Cases**	**Cases**	**Cases**	**Cases**	**Cases**	**Cases**	**Cases**	**Cases**	**Cases**	**Cases**	**Cases**	**Cases**	**Cases**	**Cases**	**Cases**
	Sum	**Sum**	**Sum**	**Sum**	**Sum**	**Sum**	**Sum**	**Sum**	**Sum**	**Sum**	**Sum**	**Sum**	**Sum**	**Sum**	**Sum**	**Total**
Aceh	22	13	56	79									79	20		269
Bali			131	2												133
Banten									2	4		6				12
Bengkulu	6		5	5						2						18
DI Yogyakarta							1		48	13	12			35		109
DKI Jakarta	160	672							6	8		49			29	924
Gorontalo									2		6	1				9
Indonesia*					306	105		630			990					2031
Jambi							419									419
Jawa Barat				2					183	219		176	365	25	8	978
Jawa Tengah	42		2	2					10	12	16	44	36	34	12	210
Jawa Timur	198	35	82	40					153	77	8	31	230	343	7	1204
Kalimantan Selatan		8	7	2				109							4	130
Kalimantan Tengah				2			6								4	12
Kalimantan Timur															109	109
Kepulauan Bangka Belitung										1						1
Lampung				1						1		2		1		5
Maluku									47	12						59

Maluku Utara									8	2	1	6	68	15		100
Nusa Tenggara Barat									3							3
Nusa Tenggara Timur						3	1		34	62		14			2	116
Papua									8	60						68
Papua Barat											1	2		5		8
Riau		7		1						1					12	21
Sulawesi Barat									5	10	41	28	56	8		148
Sulawesi Selatan	26	1	99	366		48	130	85	585	602	38	173	318	657		3128
Sulawesi Tengah		5					4		3	41	37	6			2	98
Sulawesi Tenggara										16	1	8	39	1221		1285
Sumatera Barat										1		1			1	3
Sumatera Selatan			1													1
Sumatera Utara									18	8		16	50		6	98

* Indonesia in this term is related to aggregation data of Indonesia province data in the specific period (January 2010 – June 2011; July-December 2013 and 2016)

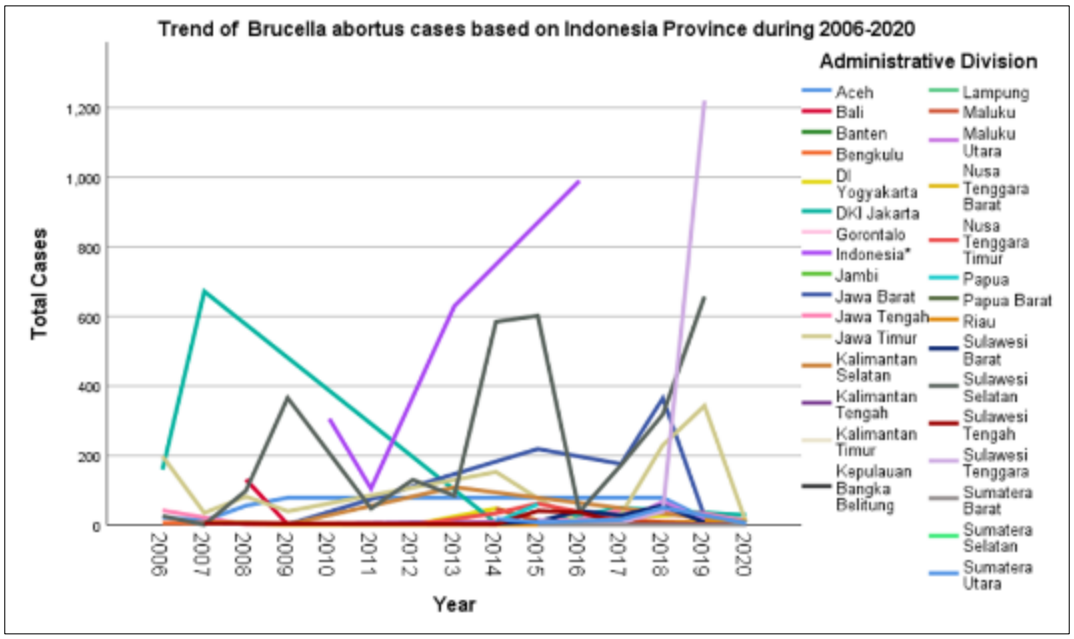

Figure 4 A line graph depicting the temporal trend of *Brucella abortus* infections across various provinces in Indonesia from 2006 to 2020. This trend demonstrates a highly fluctuating and erratic pattern in the number of reported cases. Notably, the province of Sulawesi Tenggara recorded the highest incidence of Brucellosis in the year 2019. The designation "Indonesia (*)" within the graph corresponds to instances of data aggregation from specific periods, reflecting a collective representation rather than a province-specific breakdown

Table 2 Clustering Data of *Brucella abortus* infection cases in Indonesia (2006-2020) based on Animal Species

	Animal Species				
	Buffaloes	**Cattle**	**Goats**	**Sheep**	**Swine**
	Cases	**Cases**	**Cases**	**Cases**	**Cases**
Year	**Sum**	**Sum**	**Sum**	**Sum**	**Sum**
2006		454			
2007		741			
2008		382	1		
2009		502			
2010	39	266	1		
2011		156			
2012		561			
2013	2	822			
2014	1	1110	3	1	
2015		1126	15	7	4
2016		1151			
2017	2	528	19	5	9
2018	3	1226	4	8	
2019		2357	7		
2020		196			
Total	47	11578	50	21	13

The study further delves into the incidence of *Brucella abortus* infection among various animal species. According to the WAHIS database, between 2006 and 2020 in Indonesia, five animal species were identified as susceptible to *Brucella abortus* infection. These species include Buffaloes, Cattle, Goats, Sheep, and Swine. Of these, Cattle exhibited the highest infection rate, accounting for 98.88% of the cases (as detailed in Table 2 and Figure 5). The prevalence of Brucellosis in Cattle was notably dominant throughout the period from 2006 to 2020. Conversely, the incidence rates in the other four species remained consistently low each year, as depicted in Table 2 and Figure 6.

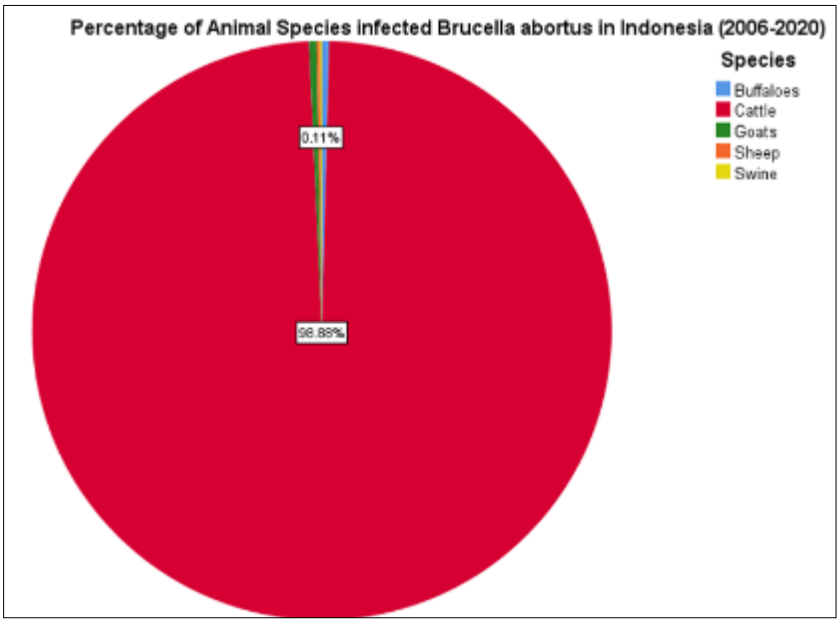

Figure 5 A pie chart illustrating the proportional distribution of *Brucella abortus* infections among different animal species in Indonesia, spanning the years 2006 to 2020. This chart distinctly highlights that Cattle are the predominantly affected species suffering from Brucellosis (98,88%) and other species had a low proportion

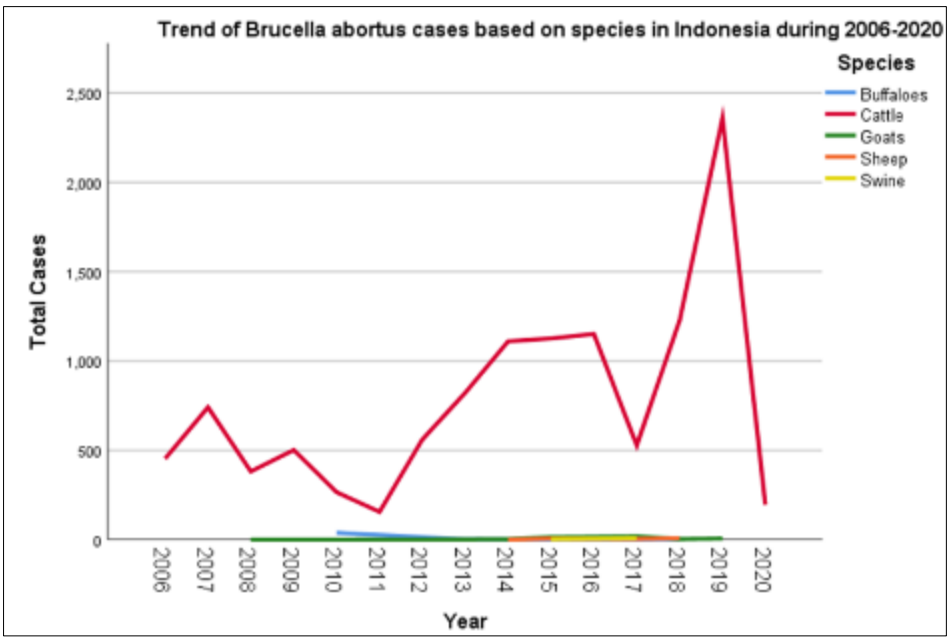

Figure 6 A line graph delineating the trend of Brucellosis incidence across various animal species in Indonesia, covering the period from 2006 to 2020. This graphical representation clearly indicates that the majority of Brucellosis cases during this timeframe predominantly occurred in Cattle

4. Discussion

4.1. Indonesia region

Brucellosis, a zoonotic infectious disease, is a global public health concern, with over 500,000 cases reported annually (25). Cases of *Brucella abortus* infection still occur in animals in all provinces in Indonesia. Based on Table 1, the largest incidence of Brucella abortion infection cases is on the island of Sulawesi, compared to other islands in Indonesia.

The incidence rate of Brucellosis in Java provinces during 2006-2020 was 3,437/11,709 (29.35%), second after to Sulawesi Island. In Indonesia, particularly in West Java, the prevalence of Brucellosis among dairy cattle is notable, with West Bandung being identified as an endemic area for the disease (26,27). The disease has also been isolated from cattle in Java as early as 1915, indicating its long-standing presence in the region (28). Setianingrum et al. conducted a study on the seroprevalence of Brucellosis and the level of reproductive disorders in dairy cows in Batu city, East Java (29). The findings indicated a low prevalence of Brucellosis (<2%) in the area, suggesting the potential for implementing a vaccination program to eradicate the disease in East Java. The results of this study are crucial for informing targeted control measures in specific regions of Java Island.

Mujiatun et al. detected the presence of Brucella species in goats at a Jakarta abattoir, reporting a 0.84% seropositivity rate (30). Although the specific Brucella species remained unknown, this study sheds light on the prevalence of Brucellosis in goats on Java Island, emphasizing the need for further research to identify the specific strains and assess their impact on public health and livestock.

Brucellosis cases on the island of Sumatra in 2006-2020 based on Table 1 were 835/11,709 (7.13%). Indonesia has not been free from Brucellosis in animals. Until 2014, several areas such as Riau, South Sumatra, Jambi, Riau Islands, West Sumatera, Bengkulu, Lampung, West Nusa Tenggara, and Kalimantan Island were noted as free areas of Brucellosis (31). This indicates that Brucellosis is prevalent in various regions of Indonesia, including Sumatra. The presence of Brucellosis in animals in these areas highlights the potential risk of transmission to humans, emphasizing the importance of understanding and addressing this public health issue in Sumatra.

Brucellosis cases on the island of Kalimantan in the period 2006-2020 were 2.14% (251/ 11,709) (Table 1). Brucellosis, a zoonotic disease, has been a concern in various regions of Indonesia, including Kalimantan. Until 2014, Kalimantan Island was noted as a free area of Brucellosis in animals, indicating the absence of reported cases . However, a recent surveillance study aimed to determine the seroprevalence of Brucellosis in East Kalimantan, indicating the need for continued monitoring and maintenance of Brucellosis status in this region (32).

Brucellosis cases on the island of Sulawesi were 4,668/11,709 (39.87%) during the 2006-2020 period (Table 1). The prevalence of Brucellosis in Sulawesi Island has been a research subject, with studies indicating the presence of the disease in cattle and goats. reported the seroprevalence of Brucellosis in Bali cattle with reproductive failure in South Sulawesi, highlighting the presence of bovine Brucellosis in cattle in South Sulawesi (28). This study provides evidence of the prevalence of Brucellosis in cattle in the region, emphasizing the need for targeted surveillance and control measures.

Additionally, conducted a survey of Brucellosis in goats using the Rose Bengal Test (RBT) and Complement Fixation Test (CFT) methods in the Gunungkidul district of Yogyakarta, reported a seroprevalence of Bovine Brucellosis (> 2%) in Sulawesi Selatan Province in 2014 (33). This further supports the evidence of Brucellosis prevalence in the Sulawesi region.

Animal health officers focused on surveillance of Brucella disease in Enrekang Regency and Bone Regency, South Sulawesi Province. Their study aimed to obtain an overview of Brucellosis transmission among these officers (34). Additionally, conducted research on zoonotic surveillance of Brucellosis in the Enrekang District of South Sulawesi Province, with the objective of assessing the risk of Brucellosis transmission among farmers, farm workers, and animal health officers in the region (35). These studies shed light on the transmission dynamics of Brucellosis and the occupational risk factors associated with the disease.

Furthermore, investigated the post-vaccination condition of Brucellosis in the Majauleng District of Wajo Regency, Sulawesi Selatan. They reported on the mass vaccination efforts using the RB51 Brucellosis vaccine in the region in 2013 and 2014 (36). This report provides insights into the vaccination strategies employed to control Brucellosis in the area.

Ratnasari et al. studied the determinants of the omp2a *Brucella abortus* antigen in local isolates, including samples from Brucellosis-infected cattle in Sulawesi Selatan and Nusa Tenggara Timur (37). This research contributes to understanding the genetic characteristics of Brucella strains in the region.

Sumitro et al. focused on the characteristics, knowledge, attitudes, and practices of animal quarantine officers in South Sulawesi in controlling Brucellosis (38). Their study aimed to identify the factors influencing the practices of these officers in Brucellosis control. This study provides valuable insights into the human factors affecting Brucellosis management in the region.

The case rate of *Brucella abortus* infection in Bali and Nusa Tenggara 2006-2020 period was 2.15% (252/11,709) **(Table 1)**. Brucellosis has been a significant concern in Bali and Nusa Tenggara, particularly in Bali cattle. Studies have indicated a high seroprevalence of Brucellosis in Bali cattle in South Sulawesi, emphasizing the endemic nature of the disease in this region (39). Additionally, research has focused on determining the antigen genotypes of *Brucella abortus* isolates in Nusa Tenggara, further highlighting the presence of Brucellosis in this area (40). These findings underscore the importance of continued surveillance and control measures to address the prevalence of Brucellosis in Bali and Nusa Tenggara, particularly in cattle populations.

The rate of Brucellosis cases in Maluku and Papua region for the period 2006-2020 was 235/11,709 (2,01%) (Table 1). The prevalence of Brucellosis in the Eastern Indonesian archipelago, particularly in the regions of Maluku and Papua, has been a subject of concern. Laboratory records from a study by revealed the presence of seropositive animals in four out of five districts in Maluku and one out of five districts in Papua, indicating the widespread nature of bovine Brucellosis in these areas (28). Additionally, emphasized the need for active disease surveillance in Papua New Guinea (PNG) and other Pacific Island Countries and Territories (PICTs) to address the re-emergence of Brucellosis, highlighting the significance of monitoring and control measures in these regions (41).

4.2. Animal species in Brucellosis case

Cases of *Brucella abortus* infection based on animal species ranging from 2006-2020 in Indonesia are dominated (98.88%) by the incidence of Brucellosis in cattle **(Table 2, Figures 5 and 6)**. In contrast, the incidence of Brucellosis in Buffaloes, Goat, Sheep and Swine were very low.

Brucellosis is a significant concern in buffalo populations, with studies indicating varying seroprevalence rates and associated risk factors. Shi et al. conducted a systematic review and meta-analysis, revealing a higher seropositive rate of Brucellosis in buffaloes living on dry land compared to those in wetlands (42). Similarly, the prevalence of Brucellosis in ruminants, including buffaloes, in Bangladesh was determined (43). This study found varying prevalence rates of Brucellosis in buffaloes in Central Punjab, Pakistan, highlighting the need for region-specific considerations (44). Furthermore, Brucellosis was reported as a worldwide re-emerging zoonotic disease (45). Additionally, Suresh et al. highlighted the contagious nature of Brucellosis, affecting various animal species, including buffaloes (46). Specific husbandry practices, such as intrauterine medication, were also identified as potential contributors to brucellosis spread among buffaloes in Delhi (47).

Brucellosis is a significant concern in goat populations, with studies indicating varying seroprevalence rates and associated risk factors. Ashenafi et al. found that caprine species and adult goats were at a higher risk of Brucella infection (48). Additionally, Saeed et al. confirmed *B. melitensis* as the causative agent of Brucellosis in goats using a species-specific PCR assay(44). Edao et al. highlighted the impact of *Brucella melitensis*, the predominant cause of human Brucellosis, in goats and sheep (49). Furthermore, a comparative study on the seroprevalence and associated risk factors of Brucellosis among sheep and goat populations in Nepal provided insights into Brucellosis's prevalence and risk factors in goats (50). The study also reported the seroprevalence and risk factors for Brucellosis in small ruminant flocks in the Southern Province of India, emphasizing the relevance of the seroprevalence of Brucellosis in goats (51). Moreover, Mellado et al. conducted a study on the sero-epidemiology of Brucellosis in small ruminants in northern Mexico, highlighting the seropositivity of Brucellosis in goats (52).

The seroprevalence of Brucellosis in sheep has been the subject of extensive research, with studies indicating varying prevalence rates and associated risk factors. Rahman et al. reported a higher prevalence of Brucellosis in sheep in the Gaibandha District of Bangladesh, particularly in sheep kept with cattle, buffalo, and goats (53). Additionally, Mola and Salib highlighted the need for appropriate serological methods for Brucellosis diagnosis in infected or endemic areas, emphasizing the significance of seroprevalence studies in sheep and goats (54). Furthermore, a study on the sero-epidemiology of Brucellosis in small ruminants in northern Mexico estimated

Brucella abortus is a significant concern in cattle populations, with studies indicating varying seroprevalence rates and associated risk factors. Assenga et al. conducted a study in Tanzania to establish the prevalence of anti-Brucella antibodies in cattle, reporting a seroprevalence of 6.8% (55). Similarly, Ibrahim et al. conducted a study in Ethiopia, reporting a lower seroprevalence of Brucellosis in cattle (56). These findings underscore the importance of understanding the prevalence and risk factors associated with Brucellosis in cattle populations for effective control and management strategies. Furthermore, the findings emphasized that *Brucella abortus* is the primary cause of Brucellosis in cattle, with *Brucella melitensis* and *Brucella suis* occasionally causing infections (57).

Based on the provided references, it is evident that *Brucella suis* is the causative agent of Brucellosis in swine. The literature indicates that swine are natural hosts for *Brucella suis*, and the infection can lead to bacteremia and chronic inflammation in the reproductive organs of both sexes (53). Furthermore, studies have reported the seroprevalence of Brucellosis in feral swine, with estimates ranging from 18% to 53% in the US, indicating the widespread nature of the disease in swine populations (58). Additionally, there have been reports of *Brucella suis* infections in wild swine, with documented cases of hunters contracting *Brucella suis* infections from wild swine in Florida (59).

Moreover, the presence of *Brucella suis* in swine herds has been highlighted, with studies indicating the recovery of *Brucella suis* isolates from the placenta of aborted pigs, emphasizing the impact of the infection on reproductive health in swine herds (60). The potential for cross-transmission of Brucellosis among different species, including cattle, swine, sheep, and goats, has also been noted, indicating the complex epidemiology of the disease and the need for comprehensive surveillance and control measures (61).

5. Conclusion

The study concluded as follows:

- The trend of *Brucella abortus* infection in the Indonesian province from 2006 to 2020 exhibited a marked degree of fluctuation, with the highest total number in Sulawesi Selatan and Sulawesi Tenggara reported the highest number of cases of Brucellosis in 2019.
- Cattle overwhelmingly comprised the dominant group of animals infected by *Brucella abortus* in Indonesia during the period spanning 2006 to 2020.

Compliance with ethical standards

Acknowledgement

The authors express the acknowledgement to WOAH/OIE for the permission using its quantitative data of *Brucella abortus* in Indonesia from 2006-2020 by WAHIS open source database (https://wahis.woah.org/#/home)

Disclosure of conflict of interest

The authors declare no conflict of interest.

Statement of ethical approval

The investigators contended that this study was exempt from ethical approval requirements, citing its classification as a mere exercise in extensive data analysis retrospectively.

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