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Abstract

The aim of this study was to examine the state of biosecurity measures on selected pig farms in the Republic of Srpska. During the study, which was conducted during 2019, a total of 35 pig farms of different capacity and direction of production from the entire territory of the Republic of Srpska were examined. Data on the state of biosecurity measures on the examined farms were collected using a survey, which, in addition to basic data on the farms, contained a series of questions on the implementation of preventive and hygienic measures on the farms, monitoring of pigs' health, hygienic conditions on the farms, and the supply of food and water as elements that can influence the level of biosecurity on farms. The results of this study have shown that the state of biosecurity

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Key words: biosecurity, preventive measures, diseases, pig farms

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Key words: biosecurity, preventive measures, diseases, pig farms

Introduction

Intensive pig production is based on raising a large number of pigs in a limited space, in order to be as economical and profitable as possible, which can represent a significant risk factor for the occurrence and spread of infectious and other diseases (Horst et al., 1997, Stark, 1998). In order to prevent the introduction and spread of diseases in the herd, and their adverse impact on the pigs' health and production results, and thus the economic effect of production, it is necessary to apply a series of preventive measures, which form an integral part of the concept of biosecurity on farms (Stanković & Hristov, 2009). According to Barcelo and Marco (1998), biosecurity is defined as a set of health surveillance measures and other preventive measures on farms, aimed at preventing the introduction and spread of infectious disease agents on farms. Although the focus of biosecurity is aimed at controlling the causative agents of infectious diseases, i.e. microorganisms, the consistent implementation of biosecurity measures also prevents the occurrence of diseases caused by non-living agents, and reduces the impact of unfavourable environmental factors on the animals being raised, thus contributing to their better health and achieving higher production and economic results, while preserving the environment at the same time (Uhlenhoop, 2007, Nitovski et al., 2010, Ostović, 2019).

The three basic elements of biosecurity on farms are, following Bojkovski (2015) and Ostović (2019a), isolation, movement control, and sanitation. According to these authors, isolation as an element of biosecurity on farms is aimed at preventing direct or indirect contact of animals present on the farm with other animals of the same or other species, as well as controlling the contact of animals of different age and production categories within the same farm. Animals that are kept outside have an increased risk of being introduced to infections that originate outside the farm, because they can come into contact with wild animals and, thereby, increase the risk of introducing diseases such as classical swine fever, African swine fever, Aujecki's disease, *Brucella* spp., *Mycoplasma*

hyopneumoniae, and swine reproductive and respiratory syndrome virus (Artois et al., 2002, Vengust et al., 2006, Acinger Rogić, 2019, Ostović, 2019b, Nielsen et al., 2021). The focus of isolation as a biosecurity measure is to prevent the introduction of microorganisms into the farm and to reduce the possibility of transmission of microorganisms from sick or carrier animals to healthy animals within the farm (Ellis-Iversen et al., 2011). The second element of biosecurity, movement control, includes controlling the entry and movement of people, animals, and vehicles around the farm and within it, as well as controlling sources from which food, bedding, medicines, equipment, and other supply come to the farm, which may represent a potential source of microorganisms or other causative agents of infectious and other animal diseases. As an important part of this biosecurity element, Bojkovski et al., (2009) state that it is necessary to keep accurate records of the entry of people, animals, vehicles, food, and equipment into the farm, as well as their movement within the farm itself. Sanitation, as the third element of biosecurity on farms, includes regular implementation of hygienic and preventive measures on farms, with an emphasis on cleaning and washing facilities, disinfection, desinsection, deratization, and deodorization, and especially the collection and safe removal of animal waste and other waste generated on farms, which can represent a source or route of transmission of infectious and other disease agents (Uzelac & Vasiljević, 2011, Delić-Jović et al., 2012, Plavša et al., 2026, Ostović, 2019a, Ostović et al., 2022). Sanitation measures should also be accompanied by appropriate records of their implementation, which prove how frequently these measures are implemented.

Stanković et al. (2007c) and Nitovski et al. (2010) state that the most important aspect of biosecurity on farms is to preserve the target level of herd health and welfare of pigs, with the application of biosecurity measures as an integral part of production technology, and the provision of optimal housing, feeding, and care conditions, in order to achieve the desired production and economic results. They also state that farmers and experts who work on farms should deal with solving problems on a daily basis concerning the preservation of health, well-being, and production of animals, and point to the fact that the occurrence of many diseases can be prevented if adequate preventive measures are taken on time, primarily through the creation and implementation of biosecurity plans. High health status of the pig herd, its establishment, and maintenance through biosecurity plans implies making special criteria on health preservation, defined by the farm's veterinary service, in accordance with the specifics of each individual farm, primarily with regard to the application of preventive measures and monitoring of pig health (Valčić, 2007, Nitovski et al., 2010, Ostović, 2019a). The approach for creating biosecurity measures for a specific farm should be based on the specifics of each individual farm and factors that represent a biosecurity risk for the animals raised there (Amass & Clark,

1999, Amass, 2005, Uhlenhoop, 2007). This approach implies the creation of a written biosecurity plan on the farm, adapted to the characteristics and specifics of each individual farm in order to identify potential risks and threats to production, and, then, to create measures to overcome them (Nitovski et al., 2010, 2012, Ostović, 2019a, Rimac, 2023). Biosecurity plans on a pig farm, according to Stanković et al. (2008), should contain: a written programme for achieving and maintaining the desired level of biosecurity, primarily in terms of isolation and sanitation measures, including procedures related to purchase, delivery, isolation and introduction of new animals into the herd, specific disease control programs, such as salmonellosis, erysipelas, colibacillosis, mycoplasmosis, parvovirosis, and other diseases, vaccination programme, control of parasitic diseases, monitoring of animal hygiene conditions in facilities, care of extremities, and prevention of behaviour problems such as tail biting. For each of the listed items, there should be a clearly defined procedure for monitoring and dealing with disputed situations, together with the persons responsible for their implementation, deadlines for action, and a precise hierarchy regarding the system of responsibility.

Starting from the key factors that are considered a biosecurity risk and should be included in the biosecurity plan, Stanković et al. (2005) and Jotanović and Savić (2017) state that the purchase of new animals should be carried out under serious veterinary supervision, only from herds with a higher or at least the same level of health status and biosecurity on farms, in order to prevent the introduction and spread of diseases on the farm where the animals arrive. Vučemilo (2007) and Stanković et al. (2007c) emphasize that there is a permanent biosecurity risk of introducing infections, especially for viruses transmitted by reproductive material, such as semen doses for artificial insemination and breeding animals, which is why special attention within the creation and implementation of biosecurity plans should be paid to the health status of reproductive material. Broom and Fraser (2007) state that, in addition to general preventive measures, the key measure aiming at reducing the risk of infectious diseases and their control in the herd is the application of vaccination, according to a vaccination programme, specially designed for a given farm in accordance with the biosecurity risk assessment. When it comes to controlling movement within the farm as an element of biosecurity, Uzelac and Vasiljević (2011) point to the importance of separating different age and production categories of pigs and state that it is necessary to have a logical schedule for visiting the farm for employees and potential visitors, from a cleaner to the dirtier part, from healthy animals to sick ones, and from younger categories of animals to older ones. According to Stanković and Hristov (2009) and Ostović (2019), all farm employees and visitors should be aware of their role in preserving the health status of the farm and the level of biosecurity, while actively participating

in establishing and maintaining the biosecurity system on farms. Bojkovski et al. (2009) state that within the framework of the creation and application of biosecurity measures on farms, it is necessary to keep precise records of the entry of staff, visitors, and animals into the farm, which should be strictly controlled and allowed only to employed persons, delivery of food, medicine, water, material, or some other categories, all with prior notice to the responsible person on the farm. Ostović et al. (2022) emphasize the importance of hygiene measures before employees and visitors enter the farm, as well as during their movement within the farm, which include showering, washing hair, using clean underwear, work clothes and shoes, as well as the mandatory disinfection of hands and shoes of all persons entering the facilities, whether they are farm employees or visitors. At the entrance to the farm, but also at each individual facility, there should be a barrier for disinfecting workers' footwear and equipment that is brought into the facility. According to Bojkovski et al. (2013), the spread of infectious agents through equipment can be reduced by taking the following measures, defined through the biosecurity plan, by washing hands before and after each entry into a particular segment of the farm and after working with animals, whether they are healthy or sick, by wearing protective gloves when helping with farrowing, using separate equipment for working with food and manure, using disposable needles during any animal treatments, sterilizing surgical instruments for castration and other operations on animals, as well as marking equipment and regular washing of work clothes with detergents and hypochlorites. Rodents and the diseases they can transmit are a serious problem on farms, which is why Đedović et al. (2015) and Ostović (2019) state that the control of the rodent population, as well as other potential carriers of infectious and other diseases, such as pigeons and insects, should be a mandatory part of any biosecurity plan, namely through the construction of facilities where they cannot penetrate, closing places for them to hide and reproduce, eliminating the possibility of their feeding, and controlling the number of the existing population in an appropriate manner. Uzelac and Vasiljević (2011), Delić-Jović et al. (2012), Jotanović et al. (2012) and Plavša et al. (2016) assert the importance of timely and proper removal of carcasses of dead animals and other animal waste for the establishment and maintenance of good biosecurity conditions on farms, because this type of waste is often a source of contamination and infection for animals present on the farm. Broom and Fraser (2007), Ramirez (2009), and Kaić (2024) also point to the importance of good hygienic and microclimate conditions for pigs raising to achieve a high level of biosecurity, with a special emphasis on an efficient ventilation system, and regular implementation of hygiene measures in facilities for the accommodation of animals, especially during their introduction to facilities, in order to reduce the possibility of infection of newly arrived animals

with microorganisms present in the facilities, left over from the animals that previously stayed in those facilities.

Stanković et al. (2005) and Bojkovski et al. (2009, 2015) state that the previously mentioned procedures and measures for preventing the entry and/or spread of disease, i.e., the application of biosecurity measures on our farms are rarely carried out systematically, which often results in a low level of biosecurity and the frequent occurrence of pig diseases, a decrease in the level of production, economic losses, and other problems, and sometimes it can even endanger the survival of the farms. Bearing in mind the above, the aim of the study was to examine the state of biosecurity measures on selected pig farms in the Republic of Srpska.

Material and Methods

The study, which was carried out during 2019, included a total of 35 pig farms from different regions of the Republic of Srpska, from the areas of Lijevče Polje, Posavina, Semberija, and Herzegovina (municipalities of Gradiška, Laktaši, Srbac, Prnjavor, Derventa, Šamac, Bijeljina, Ljubinje, Nevesinje, Bileća, Trebinje, Foča, and Pale). The selection of farms was carried out using a random selection method, where the emphasis was placed on municipalities where pig production is developed or on specific farms that have a special significance for a certain area. Data on the level of biosecurity were collected through a questionnaire, which contained questions relating to basic information about farms (size of holdings, number of employees, number of pigs by category), and the implementation of preventive measures on farms, methods of feeding and feeding, and animal hygiene conditions on farms, as elements that can influence the level of biosecurity (Table 1).

Tab 1. Elements of biosecurity on the surveyed farms included in the questionnaire

Implementation of preventive measures
Is the farm fenced?
Is there a disinfection barrier at the entrance to the farm?
Is there a disinfection barrier at the entrance to each production facility?
Do workers use a separate wardrobe for each production facility?
Are disposable clothing and shoe covers provided for visitors and other persons entering the farm?
Is there a mandatory hygiene protocol when entering the farm and production facilities?
Is there equipment for disinfecting and cleaning facilities?
Is the equipment used in production facilities regularly disinfected?
Is there a defined area for the disposal and safe disposal of animal waste?
Are sick and suspicious animals isolated from other animals on the farm?
Is deratization and other pest control measures carried out regularly?
Nutrition and water supply
What type of feed do you use to feed the pigs on the farm?
Do you produce your own animal feed or do you buy it from the market?
Do you carry out regular control of the quality and safety of the feed?
Is there adequate storage space for feed?
Is water for drinking, washing, and cleaning always available in sufficient quantities?
Do you use water from a natural source or from a public water supply?
Do you regularly check the hygiene and quality of the drinking water used on the farm?
State of hygienic and microclimate conditions in facilities
Do you use natural or artificial ventilation in pig housing facilities?
Do you monitor air temperatures in different production facilities?
Assessment of air quality in facilities for housing pigs (on a scale of 1-5)
Do you perform additional heating of facilities for housing pigs in the winter period?
Rating of cleanliness of animals (on a scale of 1-5)
Do you have a defined method and place for safe removal of animal waste?
Does the farm have a properly constructed tank with sufficient capacity to receive and store pig manure?

Basic information about the examined farms, as well as the data on their state of biosecurity, collected through the questionnaire, are presented in the table, i.e., in the form of percentages for the implementation of individual biosecurity measures on the farms in relation to the total number of farms. Also, the state of biosecurity on the those farms and in pig production in the Republic of Srpska is presented through a SWOT analysis.

Results and Discussion

Basic data about the farms

Basic data about the examined farms are presented in Table 2.

Tab 2. Basic data about the examined farms (n=35)

Parameter	**M±SD**	**Min - Max**
Farm holding size (ha)	15.66±22.14	0.23-110
Area of land under lease (ha)	2.06±7.60	0.00-40.00
Number of permanent employees	1.14±2.58	0-10
Number of seasonally engaged workers	0.24±0.82	0-4
Number of household members working on the farm	2.44±1.01	0-4
Number of gilts	17.78±25.76	3-140
Number of sows	50.26±65.97	6-350
Number of suckling piglets	118.36±134.29	10-650
Number of weaned piglets	180.31±205.67	20-950
Number of fattening animals	138.03±238.08	0-1050
Number of boars	2.03±1.92	0-10

From the data shown in Table 2., it can be seen that a very high interval of variation was present for all examined parameters, which indicates that there is a large unevenness in terms of available production resources and capacities of the examined farms. These data reflect the insufficiently regulated state of pig production in the Republic of Srpska and the lack of production planning. Concerning the size of the property owned by the farms, in addition to the average value shown (15.66 hectares) and the coefficient of variation of 141.42%, it is indicative that more than half of the farms (19 of them, i.e. 54.29%) had less than 10 hectares of arable land, eight of them (22.86%) had 10-20 hectares of arable land, three farms (8.57%) had 21-30 hectares of land, two

farms (5.71%) had 31-40 hectares of land and only three farms (8.57%) had 40 or more hectares of land, as a basic resource for their own production of animal feed. Some of the farms made up for the insufficient area of land for feed production by leasing land, with an average area of leased land of 2.06 hectares. The fact that some farms did not lease land, while some leased up to 40 hectares of land, indicates significant differences regarding the need and possibility of the surveyed pig farms to lease land, as well as the availability of land intended for lease. The largest number of surveyed farms had a small capacity and employed up to ten full-time workers (an average of 1.14 workers per farm), with occasional hiring of seasonal labour. Considering the number of permanently employed workers on farms, it was found that 28 farms (80.00%) employed up to two workers, three farms employed 3-5 and 6-8 workers (8.57% each), while only one farm (2.86%) employed between nine and 11 workers. In addition to the data on the number of employed workers, the fact that the examined pig farms in the Republic of Srpska are of small capacity and mostly family farms is also shown by the fact that they employed an average of 2.44 household members. Observed in relation to the number of farms examined, the farms where up to two household members were employed dominated (24 of them, or 68.57%), while 11 farms (31.43%) employed three to five household members.

Taking int consideration the number of pigs on the examined farms, the fragmentation of production, as well as limited production capacity, is indicated by the data on the number of breeding pigs (gilts, sows, and boars) on the examined farms. The average number of gilts on the examined farms was 17.78, with prevalence of farms with less than ten gilts (10 of them, or 45.71%), followed by farms with 10-25 gilts (14 of them, or 40.00%), while there were only three farms with 55 or more gilts (8.57%). Considering the number of sows, their average number was 50.26 per farm, and in the structure of the total number of examined farms, those with 15-30 sows dominated (11 of them, or 31.43%), five farms (14.29 %) owned 51-100 sows, while there were only four large farms with over 100 sows (11.43%). The average number of boars on the examined farms was 2.03, the structure of the total number of farms dominated by those with one or two to three boars (15 farms each, i.e., 42.86%), followed by those with four and five boars (three farms, or 8.57%), while six to seven and seven and more boars were owned by one farm (2.86% each). Artificial insemination of sows and gilts was applied by 22 farms (62.86%), while the other 13 farms (37.14%) did not use this biotechnological method.

Data on the number of other categories of pigs, i.e., piglets and fattening animals, also indicate fragmented pig production in the Republic of Srpska. The average number of suckling piglets on the examined farms was 118.36, and the average number of weaned piglets was 180.31, with farms with 100-300 piglets dominating (15 of them, 42.86%), followed by those with up to 100 piglets (10

of them, 28.57%), 301-600 piglets (three farms, 8.57%), farms with 601-900 piglets (six farms, 17.14%), while the study included only one farm (2.86%) with 900 or more piglets. Slightly more than a third of examined farms (12 of them, 34.29%) did not have a fully rounded production cycle, up to the rearing of fattening animals as the final product, which may also indicate fragmentation of production and disordered state of pig production in the Republic of Srpska, because significant number of pigs is not fattened, but delivered to the market as piglets. On the other 23 examined farms, where the production cycle was completed, the fragmentation of production is indicated by the fact that small farms, with less than 50 fattening pigs (nine of them, 39.13%) dominated, followed by large farms, with over 200 fattening pigs (eight of them, 34.87%), farms with 50-100 fattening pigs (four of them, 17.39%) and farms with 151-200 fattening pigs (two farms, 8.70%).

State of biosecurity on the examined farms

Barcelo and Marco (1998) define biosecurity as the application of health surveillance and preventive measures to prevent the introduction and spread of infectious disease agents in herds, while Bojkovski (2015) states that there are three basic elements of biosecurity on pig farms, i.e., three "pillars" on which it rests, namely isolation, control of movement, and sanitation. Considering the application of isolation, as the first level of biosecurity and the first "line of defence", it was found that almost two-thirds of the examined farms (65.71%) were not fenced, so they were not isolated from the entry of other domestic and wild animals and people, as a potential source of infection. Artois et al. (2002), Acinger Rogić (2019), Ostović (2019b), and Nielsen et al. (2021) state that the risk of infection in animals that are kept freely or on farms that are not fenced and can come into contact with other domestic and wild animals is higher compared to animals that are isolated from contact with others. An additional risk factor for the introduction of a disease within the examined farms or its spread to other objects and animals in them was a lack of disinfection barriers for people and vehicles on most of the examined farms (91.43%), even in those that were fenced. The absence of fences and debarriers at the entrance to the majority of surveyed farms, despite the importance and simplicity of applying these two measures to prevent the introduction of diseases, indicates an insufficient level of awareness among farmers about the ways and means of transmitting infectious and other disease agents from one farm to another, as well as within the farm itself, indicated by Amass and Clark (1999), Ostović (2019), and Rimac (2023), who state that the ways of transmission of infectious agents can be direct, through mutual contact of infected animals with healthy ones, but also indirect, through contaminated equipment, goods, vehicles, humans, and vector animals.

Having in mind measures intended to control the transmission of diseases within farms, the results of this study indicate a slightly higher, but still low level of farmers' awareness of the importance of using desinfective barriers to prevent the transmission of diseases within the farm, because only 17.14% of farms had desinfective barriers at the entrance to production facilities. The importance of hygienic measures and procedures when working in facilities for animals was also not recognized by farmers, because on 62.86% of farms workers used the same wardrobe for each production facility and by doing so created the risk of disease and infection transmission from one to another facility. Although visitors represent a significant risk factor for introducing infectious agents to the farm, especially if they are traders, veterinarians, or people who visit several farms in a short time, the most of examined farms (88.57%) did not provide disposable clothing for visitors, such as single-use coats and shoe sheets. Basic hygiene procedures and protocols when entering the facilities on the farm, such as washing hands, showering, and using clean work clothes and shoes, are carried out only on slightly less than a third of the surveyed farms (31.43%). In this regard, Ostović et al. (2022) point to the importance of applying hygiene measures, primarily in terms of the use of clean work clothes and shoes, regular hand and hair washing and showering , and certainly regular disinfection of hands and shoes of all persons who enter facilities for animals, whether they are employed at the farm or visitors to the farm. The results of this study have shown that 71.43% of surveyed farms had equipment for cleaning and disinfecting buildings, and regular disinfection of this equipment was performed on slightly less than two-thirds (62.86%) of the examined farms. Bearing in mind that most of the examined farms were of small capacity and with a small number of workers, who were forced to often move from one facility to another, the existence of the mentioned desbarriers and regular disinfection of hands and equipment for work with animals could be characterized as key measures to prevent the transmission of microorganisms between different facilities and different categories of pigs within the same farm (Ostović, 2019, Alarcón et al., 2021).

One of the additional potential sources of infection, through which microorganisms are easily and quickly transferred from infected animals to healthy ones, is equipment for marking and artificial insemination, surgical instruments, injection needles and syringes, and other equipment for work with animals, especially if they are not disinfected after work with animals that are potentially infected with microorganisms, and in this way they can become secondary sources of infection. Also, the activities of the veterinary service and animal marking services can represent an iatrogenic way of transmission of infection, which is why they should be accompanied by regular disinfection of hands, instruments, and equipment used when working with animals (Vučemilo,

2007, Alarcón et al., 2021). The importance of these measures is also indicated by Bojkovski et al. (2013), who state that the reduction of the spread of infectious agents and other diseases with equipment can be carried out by mandatory hand washing before each entry into any farm facility and after work with sick animals, by wearing protective gloves when helping with farrowing, using separate equipment for work with feed and manure, using single-use needles, sterilizing instruments for castration and marking, and washing work clothes with detergents and hypochlorites.

Dead animals and other kinds of animal waste, primarily manure, represent a significant potential source of infection, which is why special attention should be paid to their disposal and safe removal (Uzelac & Vasiljević, 2011, Delić-Jović et al., 2012, Plavša et al., 2016). This type of waste on farms is generated continuously and in significant quantities, and the results of this study showed that the importance of its removal was adequately recognized in slightly more than two-thirds of the surveyed farms (68.57%), which had a clearly defined method and place for disposal of animal waste (livestock cemeteries, grave pits, or other types of safe removal). Regardless of the high percentage of farms included in this study that had a defined way and place for disposal and safe removal of animal waste, it can be said that this issue on our farms is generally not solved in a satisfactory way. In this regard, especially when it comes to the disposal of carcasses as the most critical type of animal waste, systematic and continuous support from the state is necessary, through the construction of incinerators and rendering plants that would function on a regional basis and dispose of animal carcasses, slaughterhouse and other animal waste from a wider area (Delić-Jović et al., 2012, Jotanović et al., 2012, Plavša et al., 2016). Also, as regards disposal and safe removal of animal waste the state could provide support for the construction of biogas plants on farms, and the energy produced in these plants could be used for heating buildings or generating electricity (Vorkapić et al., 2012).

Separation of sick and disease-suspected animals from healthy ones is another biosecurity measure implemented within the farm, with the aim of preventing the spread of microorganisms and diseases within the farm (Vučemilo, 2007, Uzelac & Vasiljević, 2011). The results of this study showed that 60.00% of the examined farms had a separate facility for sick or suspected pigs or another type of spatial separation from healthy pigs, in order to prevent their mutual contact and the spread of the disease. This result indicates that farmers did not fully recognize the importance of physically separating sick and disease-suspected animals from healthy ones, in order to prevent the further spread of the disease, and that in the future it is necessary to work on raising farmers' awareness of the importance of this biosecurity measure. Considering the purchase of breeding animals as a potential source of infection, as pointed

out by Stanković et al. (2005, 2007c) and Jotanović and Savić (2017), the results of this study have shown that a significant number of the farms do not implement isolation or quarantine measures when purchasing new animals, and immediately introduce them to the herd, before their health status is validated. The examined farmers have a similar approach when it comes to purchase of insemination doses of semen for artificial insemination, which indicates an insufficient level of awareness of the importance of the health status of pigs on the farm from which they purchase insemination doses and the possibility of transmission of infectious and other disease agents this way, which, with wide use of artificial insemination in today's pig production, represents a significant biosecurity risk factor (Jotanović et al., 2019, Savić isar., 2020). Vučemilo (2007) and Vidović et al. (2011) state that keeping different categories of pigs in separate facilities, and their spatial separation in the sense that especially sensitive categories such as suckling piglets are kept away from fattening and other categories of adult pigs, have a favourable effect on reducing the possibility of transmitting microorganisms and diseases within the farm. This measure can be considered as one kind of isolation of sensitive categories of pigs within the farm, as an element of biosecurity that should contribute to reducing the frequency of disease occurrence on farms and their spread within farms (Alarcón et al., 2021).

According to Stanković and Hristov (2009), employees and visitors to the farm should be aware of their role in preserving the safe health status of the farm, and the biggest responsibility in protecting against the introduction and spread of diseases within the farm lies with the farmers, who should properly handle and group the animals, implement sanitary measures, and control the movement of vehicles, people, animals, and supplies. In addition to the already mentioned lack of use of disposable shoe covers and special coats for visitors, the results of this study indicate serious omissions on the examined farms and in relation to the second "pillar" on which biosecurity on farms rests, the control of the movement of people, animals, and goods, above all because a significant number of the examined farms were not fenced, nor did they have a desbarrier at the entrance for vehicles and people. As already stated, a special risk for the transmission of diseases from one farm to another due to the lack of control over the movement of vehicles and people is represented by animal traders, as well as vehicles that deliver feed and other goods to a large number of farms. At the same time, the risk of introducing diseases through vehicles and personnel providing services for the maintenance of installations and facilities on the farm (electricians, plumbers, and similar services) should not be ignored, and certainly also through vehicles and personnel of the veterinary service, who visit several farms in a short period of time and can transfer microorganisms that cause infectious and other diseases from one farm to another on shoes and other equipment (Uhlenhoop, 2007, Stanković et al., 2008, Alarcón et al., 2021). Although this was not stated

as a question in the questionnaire itself, according to the oral information collected during the farm visits, most of the surveyed farms did not own or use special coats, boots, and other protective equipment that the veterinary service would use when staying and working on the farm, with the aim of reducing the risk of introducing microorganisms from other farms on shoes and other equipment.

The presence of vectors, which can transfer microorganisms that cause infectious and other diseases from farm to farm, and between different facilities within the same farm, also represents a significant risk factor for biosecurity on farms (Valčić, 2007, Stanković et al., 2008, Uzelac & Vasiljević, 2011, Alarcón et al., 2021). Pig nutrition, mostly concentrated feed often inappropriately stored encourages the maintenance of the rodent population on farms, primarily mice and rats, but also pigeons, sparrows, and other birds, which are often carriers of infectious and other diseases. The presence of rodents and other vectors on pig farms often attracts other species of animals, such as dogs, cats, and birds of prey, whose presence can also represent a significant risk factor for the introduction and spread of disease from one farm to another and within the same farm. In order to reduce their number, and the possibility of them becoming a path and a way for the causative agents of diseases to be transferred from infected animals to healthy ones, it is necessary to continuously implement preventive measures, above all measures of deratization and desinsection, and control of the bird population. Đedović et al. (2015) state that the control of the population of rodents and other vectors should be a mandatory part of every biosecurity plan. The results of this study, in contrast to most other biosecurity items, indicate that the importance of continuous preventive pest control is recognized on almost all examined farms (91.43%), and it can be said that farmers' awareness in this regard is at a very high level, most likely because the presence of rodents on the farm can lead to the occurrence of trichinelosis in pigs and the economic losses caused by this parasitic disease. According to the oral information collected during the farm visits, most of the examined farms used some form of insect population control, most often through the use of adhesives, treating windows and other surfaces where insects are kept with insect repellents, which is why it can be said that this preventive and biosecurity measure is implemented on the majority of surveyed farms.

The nutrition of pigs, in terms of the source of feed, its quality and safety, as well as the way of feeding, is one of the key factors of successful pig production, but at the same time it is also an important segment of biosecurity on pig farms. In addition to having a direct effect on the growth and general resistance of the pig organism through its composition, feed can be a significant source of infection for pigs on farms, because it can be contaminated with infectious and other disease agents, or be spoiled due to inadequate storage.

Considering the source of feed supply, the majority of the examined farms based their pig nutrition on their own feed production in whole (40%) or partially (37.14%), while a smaller number of farms purchased feed from the market (20%). Avakumović (2006) states that, for farmers who do not produce feed themselves, but purchase it on the market, it is crucial to choose a feed supplier or producer who has a clearly defined and controlled regime of its production, quality control, and safety, preferably through an established traceability system. Considering the possibility of spoilage or contamination of feed during production, transportation, keeping, and storage, an important item in ensuring biosecurity on pig farms in this part is regular control of the quality and safety of feed used. The results of this study have shown that the largest number of the examined farms (51.43%) did not control the quality and safety of feed used, slightly more than one third (37.14%) did it regularly, while the rest of the farms did it when necessary, most often after some health or other problem in pigs appeared. This indicates that the fact that food with a bad taste, contaminated with microorganisms, or unbalanced in terms of nutrient content, can greatly affect the health and production results of pigs on farms, is not sufficiently recognized by farmers, and that in future much more attention should be devoted to raising the level of farmers' awareness of in this segment of production. At the same time, the results of this study have shown that most of the examined farms (88.57%) had facilities for feed storage adequately protected from bad weather and rodents, which ensured the conditions for preservation of its composition, quality, and safety.

Pig farms are large consumers of water, especially for washing and cleaning facilities, which is why it is necessary to ensure their continuous water supply (Schlink et al., 2010). If its quality and hygienic properties do not meet the necessary standards, water can be a significant source of infection for pigs on farms and the path of their spread, especially for microorganisms that are excreted through urine, such as Leptospira species (Stanković et al., 2008, Alarcón et al., 2021). The results of this study showed that water for drinking and maintaining hygiene on farms was continuously available in sufficient quantities on 88.57% of the examined farms, while a smaller number of farms (11.43%) did not have a continuous supply of water, which represented a significant problem in their functioning. The importance of controlling the quality and hygienic properties of water for pigs on the examined farms was not sufficiently recognized by the farmers, because slightly less than half of the examined farms (45.71%) did not carry out regular quality and hygienic controls of the water used for pigs, 17.14% performed this type of analysis sometimes, when necessary, while slightly more than a third (37.14%) carried out these controls regularly. The location of the farms, i.e., the availability of commercial water supply systems, determined the source from which the farms are supplied with water,

and the results of this study have shown that approximately the same percentage of farms are supplied with water from their own water sources and from the commercial water systems (48.57 vs. 51.43%)). Bearing in mind that water from commercial water supply systems is subject to regular quality and hygienic control, it is to be expected that on farms that are supplied with water from these systems, the possibility that the drinking water for pigs and maintaining hygiene in the facilities for their accommodation will become a source of infection is much smaller compared with those farms that are supplied with water from their own sources, especially if they do not have issues with disposal of manure from facilities and other types of animal waste has been adequately resolved (Hristov, 2002).

Pig farms and facilities within them represent the environment in which pigs live during their entire production life, so it is necessary to provide appropriate microclimatic and hygienic conditions in them, in order to achieve optimal production and preserve health (Uzelac & Vasiljević, 2011, Kaić, 2024). Broom and Fraser (2007) point out the importance of good hygienic, spatial, and microclimate conditions with an emphasis on an efficient ventilation system as one of the key measures to protect the health of pigs on farms. Natural ventilation is usually not able to provide a sufficient number of air changes in facilities for housing pigs in a unit of time, especially in facilities with a larger capacity, which is why a significant number of farms rely on artificial ventilation or a combination of artificial and natural ventilation (Kaić, 2024). The results of this study showed that the combined ventilation system was used by slightly less than half of the surveyed farms (45.71%), while an approximately equal number of farms relied only on natural (28.57%) or only on artificial ventilation (25.71%). The temperature in facilities is an important microclimate factor, especially for sensitive categories of pigs, such as suckling and weaned piglets, which need to be provided with a slightly higher ambient temperature compared to adult pigs, which implies monitoring the temperature values in the facilities for their accommodation. Although they are far less sensitive to low ambient temperatures, adult pigs also require a certain temperature range to achieve optimal production results, and there is a need to monitor temperatures in facilities for these categories of pigs as well. Ramirez (2009) states that the temperature and humidity of the air in facilities for housing pigs should be adjusted to appropriate values no later than the day before the animals move into the facility, which indicates the importance of monitoring the temperature in the facilities. The results of this study showed that slightly less than a third of the examined farms (31.43%) kept records of the temperature values in the facilities for the accommodation of certain categories of pigs, while the majority of the farms (82,86%) used additional heating during winter period, mostly in facilities for housing sows with piglets and facilities for rearing piglets.

Another important factor of the microclimate in facilities for housing pigs is the air quality, in terms of the concentration of harmful gases and dust, which are created by the decomposition of organic matter from food, manure, and other types of waste generated in the facilities, as well as by the breathing of animals (Hristov, 2002). As part of the visit to the farms, a subjective evaluation of the air quality inside the facilities was also carried out, on a scale of one to five, with five being the best and one being the worst. The results of this study showed that the air quality on most of the examined farms was satisfactory, because the largest number of farms were rated four (42.86%) and five (34.29%), while a smaller number of farms had worse air quality in the buildings (20.00% of farms with a rating of three and 2.86% of farms with a rating of two). Air quality, in addition to ventilation, is directly related to the maintenance of hygiene in buildings, primarily in terms of cleaning, which is also reflected in the degree of cleanliness of the animals' bodies, especially in facilities where bedding is not used (Hristov, 2002). The farmers' awareness in this regard and the generally good maintenance of hygiene in facilities for housing pigs on the surveyed farms are also indicated by the results of the subjective assessment of the cleanliness of the animals' bodies, which showed that the largest number of farms for this segment of the research were rated five (42.86%) and four (31.43%), while 25.71% of surveyed farms received a grade of three.

Pig production continuously produces manure and other forms of animal waste, which can represent a risk factor for the occurrence and spread of diseases, which is why this type of waste should be disposed of in an appropriate manner, i.e., safely removed (Plavša et al., 2009, 2016, Delić- Jović et al., 2012, Jotanović et al., 2012, Ostović, 2019). The results of this study have shown that slightly more than two-thirds of the examined farms (68.57%) had a defined way of disposing of dead animals (cattle cemeteries, burial pits, etc.). Given that pig production mainly creates liquid manure, the issue of disposal and storage of pig manure is solved by building tanks or lagoons for manure disposal. The results of this study showed that 71.43% of the examined farms had tanks for manure disposal, with adequate capacity in relation to the size of the farm, while the other 28.57% of the examined farms solved the issue of manure disposal in another way. In addition to the epizootiological aspect, the proper disposal of manure greatly affects the ecological aspect of farm operations, because inadequate disposal of manure can lead to contamination of water, air, and land on the farm and in its surroundings, especially in areas with a porous soil structure and a high level of underground water (Hristov, 2002, Plavša et al., 2009). In recent times, the issue of manure management has also been relevant due to compliance with the nitrate directive, which defines the amount of nitrogen that can reach the land during the year, in order to avoid soil and water contamination (Anonymous, 1991, Cvijić, 2022).

The results of this study are also presented in the form of a SWOT analysis, in which strengths, weaknesses, opportunities, and threats are identified in the application of biosecurity measures on pig farms in the Republic of Srpska (Table 3.).

Tab 3. SWOT analysis about the implementation of biosecurity measures on pig farms in the Republic of Srpska

STRENGHTS (+)	**WEAKNESSES (-)**
○ Motivation for change as a driving force for the implementation of biosecurity measures. ○ Faster adaptation of smaller farms to changes. ○ Presence of local experts to support farmers. ○ Existing infrastructure as a basis for improvement through smaller investments in adaptation and modernization. ○ Association and cooperation among farmers in improving biosecurity standards can lead to a reduction of disease risk. ○ Cooperation with faculties, research institutes, and other professional and scientific institutions can provide support and information on biosecurity measures and practices. ○ Increasing food safety awareness can motivate farmers to improve their biosecurity measures to meet consumer and market demands. ○ Farms that have high biosecurity standards can use this as a marketing advantage for their products as safe and of high quality. ○ The application of biosecurity measures reduces the risk of disease outbreaks and ensures the stability of production and the market. ○ Consumer confidence in local products, which can strengthen the local economy and provide new business opportunities for farmers.	○ Limited resources and capacities for investing in improving infrastructure and applying biosecurity measures. ○ Lack of adequate genetics increases susceptibility to diseases and reduces resistance to pathogens. ○ The lack of fences and debarriers leads to an increased risk of pathogens spreading within the farm. ○ Lack of facility sanitation measures enables the accumulation of pathogens and increases the risk of disease. ○ The absence of separate technological processes for different stages of production increases the risk of cross-contamination and the spread of disease. ○ Lack of adequate education and training for farmers on the importance of applying biosecurity measures leads to inadequate application of these measures. ○ Limited access to advanced technologies that can improve biosecurity. ○ Lack of coordination and cooperation between farms can lead to uneven biosecurity standards and make it difficult to collectively improve conditions. ○ Older and inadequate infrastructure may require additional investment to adapt to modern biosecurity standards, which may be challenging for smaller farms. ○ Insufficient support from the authorities or inadequate regulations make it difficult to maintain high biosecurity standards. ○ Farmers' resistance to changes in existing practices and the introduction of new biosecurity measures can slow down the process of improvement and modernization.
OPPORTUNITIES (+)	**THREATS (-)**
○ Financial support from the state, international funds, and non-governmental organizations. ○ Education for farmers on the importance of biosecurity measures, their implementation, and farm management.	○ Risk of outbreak of infectious diseases, especially zoonoses. ○ Increased regulatory requirements and possible penalties for failure to meet biosecurity standards

○ Introduction of new technologies for animal health monitoring, automatic disinfection systems, and digital data management. ○ Introduction and use of genetic lines of pigs that are more resistant to diseases. ○ Cooperation with academic and research institutions. ○ Adoption of new laws and regulations that require stricter biosecurity measures ○ Increased consumer awareness of food safety. ○ Development and promotion of brands based on high biosafety standards. ○ Increasing competitiveness on the international market ○ Development of the local economy ○ Use of local resources	○ Economic instability can reduce the possibility of investing in the improvement of biosecurity measures, further hampering the financial sustainability of farms. ○ Lack of support from authorities and institutions can slow down the application of biosecurity measures. ○ Small farms may have difficulty competing with large producers who have better established biosecurity measures and greater resources. ○ Increased production costs ○ Implementing biosecurity measures can present technical and logistical challenges, especially for smaller farms with limited resources and expertise. ○ Social and cultural resistance to changes and modernization of biosecurity practices ○ Global market trends.

Conclusion

The results of this study indicate significant omissions and a number of critical points regarding the application of biosecurity measures on the examined farms in all three elements of biosecurity, especially in isolation and movement control measures, as well as insufficient awareness among farmers about the importance of regular application of preventive disease control measures on farms for successful pig production. In general, the insufficiently high level of biosecurity on the examined pig farms in the Republic of Srpska has an unfavourable effect on the frequency of occurrence of various diseases, production results, and the functioning of the farms in general, so it is necessary to undertake a series of activities to correct the observed deficiencies in the future, primarily in terms of raising the level of farmers' awareness on the importance of applying biosecurity measures to preserve and improve the health of pigs, increasing cooperation between farms, the veterinary service, and competent management bodies, and improving the economic effect of pig production in the Republic of Srpska.

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Стање биосигурности на одабраним фармама свиња у Републици Српској

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Сажетак

Циљ истраживања био је да се испита стање биосигурносних мјера на одабраним фармама свиња у Републици Српској. У истраживању, које је спроведено током 2019. године, испитано је укупно 35 фарми свиња са подручја цијеле Републике Српске, различитог капацитета и правца производње. Подаци о стању биосигурносних мјера на испитаним фармама прикупљени су помоћу анкете, која је поред основних података о испитаним фармама свиња, садржала низ питања о спровођењу превентивних и хигијенских мјера на фармама, надзору над здрављем свиња, зоохигијенским условима на фармама, те снабдијевању храном и водом, као елементима који могу утицати на ниво биосигурности на фармама. Резултати овог истраживања показали су да стање биосигурносних мјера на испитаним фармама свиња у моменту истраживања није било на задовољавајућем нивоу, те да постоји потреба за идентификацијом критичних тачака за сваку фарму и израдом плана биосигурности за сваку фарму посебно, у складу са идентификованим факторима ризика и могућностима за корекцију уочених проблема.

Кључне ријечи: биосигурност, превентивне мјере, болести, фарме свиња

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