P-ISSN: 2304-3075; E-ISSN: 2305-4360
International Journal of Veterinary Science
www.ijvets.com; editor@ijvets.com

Research Article

Biosecurity Practices in High Throughput Philippine Backyard Pig Herds: A Multiple Correspondence Analysis

Wilfredo V. Andico Jr. and Santiago T. Peña Jr.*

Department of Veterinary Basic Sciences, College of Veterinary Medicine, Visayas State University, Baybay City, Leyte, Philippines 6521-A
***Corresponding author:** santiago.penajr@vsu.edu.ph

Article History: Received: May 23, 2019 Revised: July 29, 2019 Accepted: August 08, 2019

ABSTRACT

The Negros Island Region (NIR) in Western Visayas, Philippines uniquely possesses a high throughput of pig production from smallholder pig operations and has been recognized for being one of the country's consistent top backyard pig producers. In order to maintain the progress of backyard swine production in the province, at least one association of pig raisers in every town/city has been instituted. Being recognized as a leader in backyard pig production in the province, this study aimed to evaluate and highlight biosecurity practices adopted by smallholder pig farmers to raise awareness of potential biosecurity concerns and promote good biosecurity measures in place. At more than 80% response rate from door-to-door personal interviews and using multiple correspondence analysis with agglomerative hierarchal clustering technique, our study shows potential areas that need improvement making such results both a challenge and an opportunity for better production outcome. Basic biosecurity practices like deworming, disinfection, bathing of pigs, provision of pens and burying dead pigs were applied but there are still areas needing improvement especially when the purpose of raising pigs is a hobby than as a primary source of income. Membership in a pig raising association is still limited but is encouraged to support dissemination and implementation of good biosecurity practices particularly in disease prophylaxis, control of risks against disease entry and proper waste management.

Key words: Biosecurity, Pig farms, Smallholder raiser, Philippines, Negros Island Region

INTRODUCTION

While pig production is centered at ensuring top-quality pork and efficiency in production (Whittemore and Kyriazakis, 2008), smallholder backyard production system still predominates the majority of pig raising activities in the Philippines. As pork remains the most preferred meat source among Filipinos, the pig industry is the biggest player among livestock and ensues a significant portion of the countries' gross domestic product contributing as high as 558.73 thousand metric tons in the first quarter of 2018 (PSA, 2018).

One region that possesses a high throughput of pig production from backyard operation is Western Visayas, Philippines where the Negros Island Region (NIR) belongs. Western Visayas (9.92%) ranks 3rd among all regions of the country in terms of total swine inventory following CALABARZON (12.29%; 2nd) and Central Luzon (16.91%; 1st; PSA, 2018), respectively. Within the NIR, Negros Occidental on the west tops its counterpart Negros Oriental on the east and recognized for being a consistent top backyard pig producer.

In order to maintain the progress of backyard swine production in the province, several programs were implemented by the Provincial Veterinary Office (PVO) of Negros Occidental, including the establishment of at least one association of pig raisers in every town/city. Today, there are 22 recognized hog raisers associations among Local Government Units (LGUs) of the province. Interestingly, one association that seemed to excel so well in terms of stability and sustainability of operation is the Murcia Hog Raisers Association (MHRA) in Murcia, Negros Occidental. Being recognized as a leader in backyard pig production in the province, this study aimed to identify and evaluate the biosecurity practices adapted by hog raisers in Murcia, Negros Occidental. Such study may be used to highlight differences in biosecurity management practices as well as to raise awareness of potential biosecurity concerns in the farms at risks. Moreover, given the role provided by the pig raisers

Cite This Article as: Andico Jr. WV and ST Peña Jr., 2019. Biosecurity practices in high throughput Philippine backyard pig herds: a multiple correspondence analysis. Inter J Vet Sci, 8(4): 316-323. www.ijvets.com

association in the capacity building of pig farmers, this study could guide other hog raisers how such associations can influence their production.

MATERIALS AND METHODS

Study design and sampling procedures

This study was conducted in the Municipality of Murcia, Negros Occidental, Philippines (10° 36' 21.60" N, 123° 02' 20.40" E) which is politically subdivided into 23 barangays (Figure 1). Backyard pig raisers regardless of their membership in the MHRA served as respondents of the study. At 95% confidence level and a 5% margin of error, at least 376 respondents proportionally allocated and randomly selected from each barangay were required to participate in the survey from the given population of about 18, 500 (The Research Advisors, 2006). A personal door-to-door interview was conducted using a prepared questionnaire. When the randomly selected respondent was not available during the visit, not a backyard pig raiser, or simply refused to be interviewed, the next available backyard pig raiser closest to that respondent was interviewed instead.

Fig. 1: Murcia with surrounding municipalities in Negros Occidental, Western Visayas, Philippines.

Construction of the questionnaire and the conduct of the interview

The interview questionnaire was constructed and modified from earlier studies by Ribbens *et al.* (2008), Alawneh *et al.* (2014), and Armenia *et al.* (2016). It consisted of biosecurity practices that detail possible preventive measures applied by the farm to control disease incidence. The questionnaire originally constructed in English was translated into local dialect (Hiligaynon) for the convenience of the respondent. Permission to conduct the interview was requested from the office of Municipal Mayor through the respective village/barangay heads, accordingly. Interview of respondents was conducted between December 2018 and February 2019 upon due approval of the Students Research Committee of the College of Veterinary Medicine, Visayas State University. Pretesting was done to ensure the reliability and validity of the survey questionnaire. At least fifteen backyard pig raisers were randomly selected from different barangays near the Visayas State University, Baybay City, Leyte. After the pretesting, the survey questionnaire was revised accordingly while the initial data were used to conduct preliminary statistical analysis.

Data management and statistical analysis

All data were encoded and analyzed using Microsoft Excel with XLSTAT version 2019.1.2 (Addinsoft, 2018) installed for multiple correspondence analysis (MCA), agglomerative hierarchical clustering (AHC) and generation of parallel coordinates plots (PCP) following procedures found in the XLSAT Help Manual. Multiple-correspondence analysis (MCA) was used to explore and describe the relationships between different independent biosecurity variables without having to necessarily specify a dependent variable (Greencare, 1984;Tenenhaus and Young, 1985). Briefly, this technique, after assigning numerical values to cases and categories of the variables, quantifies optimal dimensions separating different variable categories as much as possible. Thereafter, the principal coordinates (F1 and F2) generated by MCA were then used for AHC and the number of clusters obtained from AHC was then used for plotting the PCP. Variables such as membership in MHRA, purpose of raising pigs and attendance in pig raising seminars were used as supplementary variables so they don't influence the MCA calculation but could provide additional information how they are positioned in the correspondence map. Optimal number of clusters was generated automatically using AHC without pre-selection of the required final number. This procedure involves clustering of relatively homogeneous groups of variables creating a hierarchy of clusters in a form of a tree-like dendrogram. Finally, parallel coordinate plots were generated to better visualize and describe the characteristics of clustered variables.

RESULTS

At 82.62% response rate, the number of samples exceeded an ideal response rate of 70% (Thrusfield, 2005 as cited by Ribbens *et al.*, 2008) thus providing us data sufficiently enough for a robust evaluation. Some reasons for our non-response include either 1) no pigs being raised near commercial buildings in the urban barangays 2) declined to be interviewed or 3) located in distant restricted areas where the researcher is not permitted for entry.

Figure 2 shows the MCA solution for the variables regarding actions taken by the respondents to control and prevent disease outbreak. The total variance explained by the solution was 52.23% (31.02% by dimension 1 and 21.20% by dimension 2). Dimension 1 was influenced primarily by provision of quarantine area (0.431), deworming (0.374), vaccination (0.372) and isolation of sick pigs (0.368) while dimension 2 was mainly influenced by swill feeding (0.620).

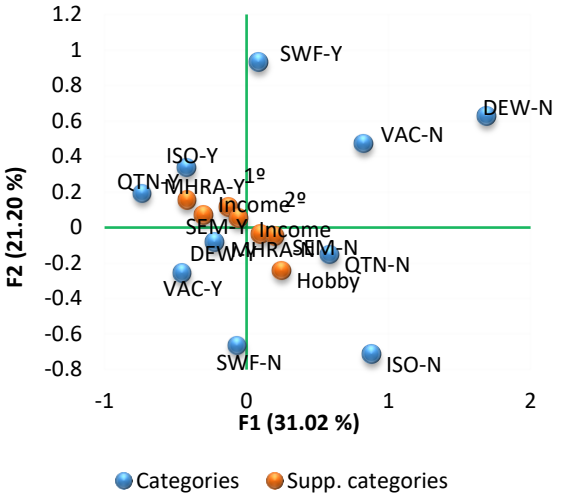

Fig. 2: Two-dimensional multiple-correspondence analysis solution of biosecurity practices related to disease prevention. n=312; dimension 1, X-axis; dimension 2, Y-axis; Y, yes; N, no; DEW, deworming practiced; ISO, isolating sick pigs; QTN, quarantine present; SEM, attendance to pig raising seminar/s; SWF, swill feeding practiced; VAC, vaccination practiced.

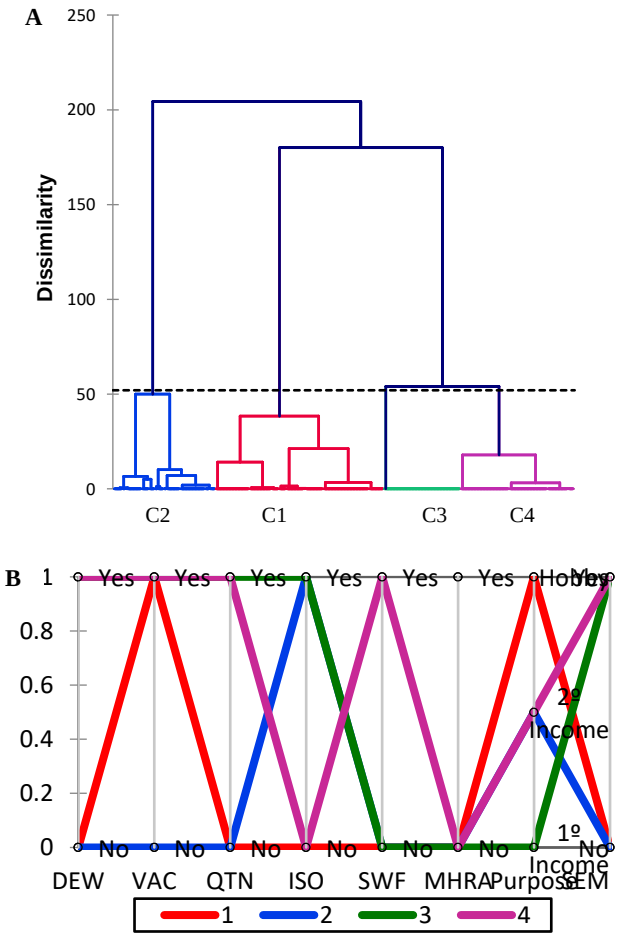

Fig. 3: Dendrogram generated by AHC (A) and parallel coordinate plot (B) of biosecurity practices related to disease prevention showing four clusters. C1-red, low biosecurity; C2-blue, low-medium biosecurity; C3-green, high-medium biosecurity, and C4-purple, medium biosecurity; DEW, deworming practiced; VAC, vaccination practiced; QTN, quarantine present; ISO, isolating sick pigs; SWF, swill feeding practiced; SEM, attending seminar/s.

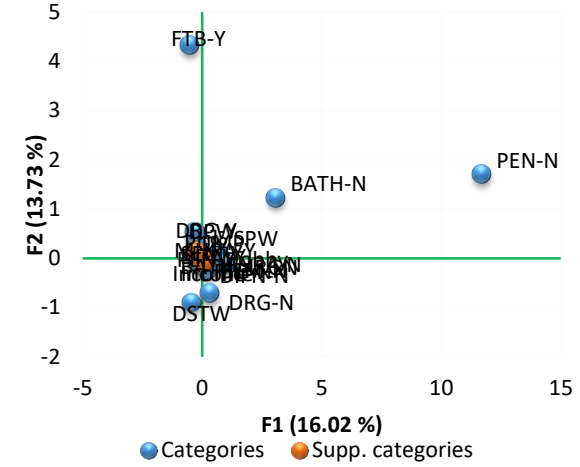

Fig. 4: Two-dimensional multiple-correspondence analysis solution of biosecurity practices related to disinfection measures. n=312; Y, yes; N, no; SEM, attendance to pig raising seminar/s; BATH, bathing pigs; PEN, provision of pens; FTB, footbath; DRG, drainage provided; DIFN, disinfection; DSTW, district water; DPW, deep well; IRGN, river irrigation; SPW, spring water; PUMP, water pump.

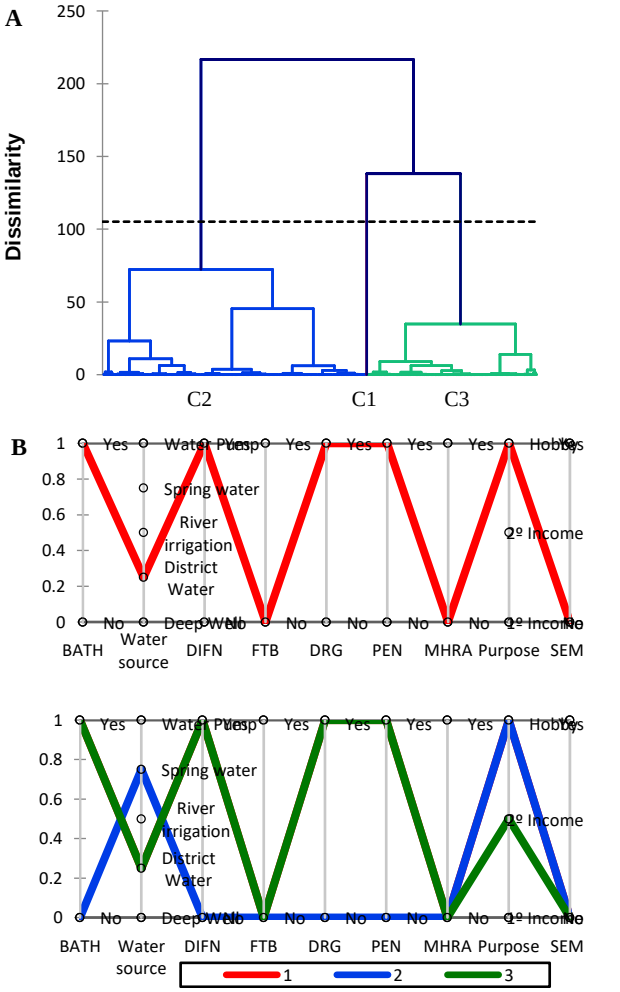

Fig. 5: Dendrogram generated by AHC (A) and parallel coordinate plot (B) of biosecurity practices related to disinfection measures showing three clusters. C1-red, medium biosecurity; C2-blue, low biosecurity; and C3-green, medium biosecurity; BATH, bathing pigs; DIFN, disinfection; FTB, footbath; DRG, drainage provided; PEN, provision of pens, and SEM, attendance to pig raising seminar/s.

It was observed that the above variables were closely associated with respondents' membership with MHRA and the purpose of pig raising is as a source of income. Attendance in pig raising seminars, quarantine and membership in MHRA did not appear to be a priority for respondents whose purpose of raising pigs is hobby. Four clusters were generated characterizing respondents' biosecurity practices related to disease prophylaxis (Figures 3A and 3B). Cluster 1 comprises 36.54% of the respondents, cluster 2 at 22.11%, cluster 3 at 16.67% and cluster 4 at 24.68%. Using PCP, these clusters are summarized as follow:

Cluster 1 (Red): Respondents of this group are mostly non-members of MHRA and only raised pigs as a hobby. Apparently, no deworming, quarantine and isolation of sick pigs were being implemented nor attendance to pig raising seminar is important. However, respondents on this group vaccinate their pigs and do not practice swill feeding.

Cluster 2 (Blue): Respondents of this group are mostly non-members of MHRA and raise pigs as their secondary source of income. Deworming, vaccination and quarantine of newly arrived pigs are not practiced except for isolation of sick pigs. They don't practice swill feeding nor attend seminars on swine raising.

Cluster 3 (Green): Respondents of this group are mostly non-members of MHRA, and they raise pigs as their primary source of income. They practice deworming, vaccination, quarantine of newly arrived pigs but do not isolate sick pigs. They don't practice swill feeding but attend seminars regarding swine raising.

Cluster 4 (Purple): Respondents of this group are mostly non-members of MHRA and they raise pigs as their secondary source of income. They practice deworming, vaccination, quarantine newly arrived pigs but do not isolate sick pigs. They practice swill feeding and attend seminars regarding swine raising.

Figure 4 shows the MCA solution for the variables regarding biosecurity practices related to disinfection. The total variance explained by the solution was 29.75% (16.02% by dimension 1 and 13.73% by dimension 2). Dimension 1 was influenced primarily by provision of pens for pigs (0.442), bathing (0.386), disinfection (0.299), and spring water as water source (0.203). Dimension 2 was mainly influenced by provision of footbaths (0.493), drainage (0.375), and district and deep well as water source (0.259 and 0.102, respectively). Most of variables are closely associated and are situated close to the origin of the axes. Three clusters were generated characterizing respondent's biosecurity practices related to disinfection (Figures 5A and 5B). Cluster 1 comprises 39.10% of the respondents, cluster 2 at 0.32% and cluster 3 at 60.58%. Using PCP, these clusters are summarized as follow:

Cluster 1 (Red): Respondents of this group are mostly non-members of MHRA and raised pigs as a hobby. Deep well is the main source of water and bathing of pigs is practiced at least once a day. Pig pens with proper drainage are provided but no footbaths. Pig pens are also disinfected before being used while attendance to pig raising seminars is not practiced.

Cluster 2 (Blue): Respondents of this group are mostly non-members of MHRA and raised pigs as a hobby. Spring water is the main source and do not necessarily have to bathe pigs once a day. The rest of the practices were similar to Cluster 2.

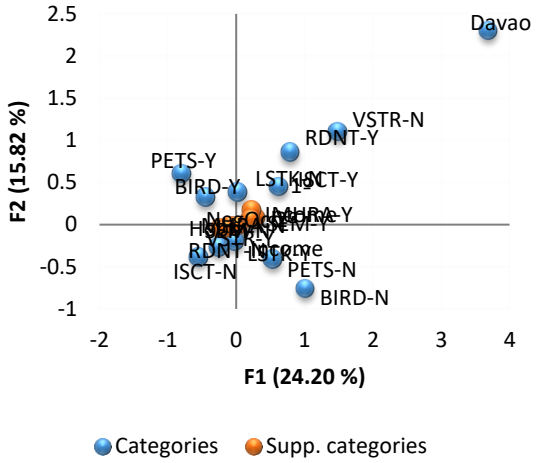

Fig. 6: Two-dimensional multiple-correspondence analysis solution of biosecurity practices related risks of disease entry. n=312; Y, yes; N, no; BIRD, bird access; ISCT, insect control; LSTK; other livestock raised; PETS, pet access; RDNT, rodent control; SEM, attendance to pig raisin seminar/s; VSTR, visitor access.

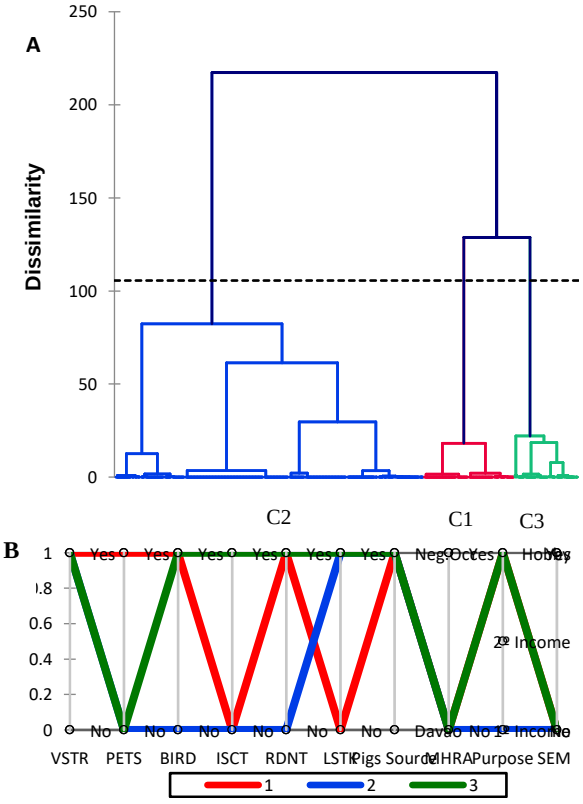

Fig. 7: Dendrogram generated by AHC (A) and parallel coordinate plot (B) of biosecurity practices related to risks of disease entry showing three clusters. C1, red, low biosecurity; C2, blue, medium biosecurity, and C3, green, high biosecurity; VSTR, visitor access; PETS, pet access; BIRD, bird access; ISCT, insect control; RDNT, rodent control; LSTK, other livestock raised; SEM, attendance to pig raising seminar/s.

Cluster 3 (Green): Respondents of this group are mostly non-members of MHRA and raise pigs as their secondary source of income. The rest of the practices in terms of source of water, bathing of pigs and pig pens, disinfection before use and attendance to pig raising seminar are similar to Cluster 1.

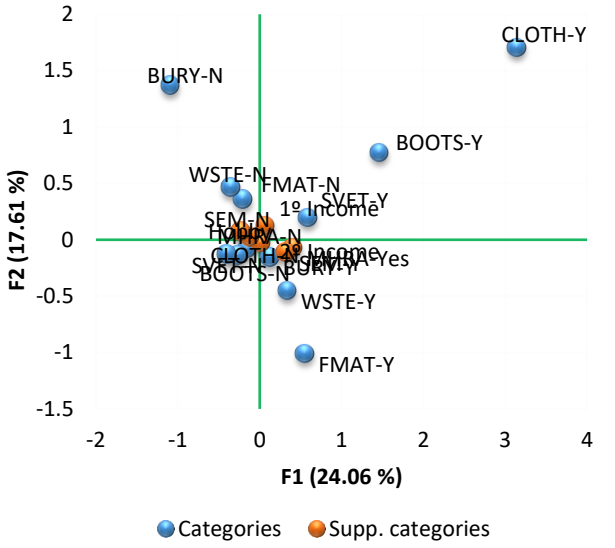

Fig. 8: Two-dimensional multiple-correspondence analysis solution of biosecurity practices related to fomites and waste management. n=312; Y, yes; N, no; BOOTS, using boots; BURY, practicing burying dead pigs; CLOTH, farm clothing used; FMAT, sharing materials from other farms; SEM, attendance to pig raising seminar/s; SVET, separate vet material; WSTE, proper waste disposal.

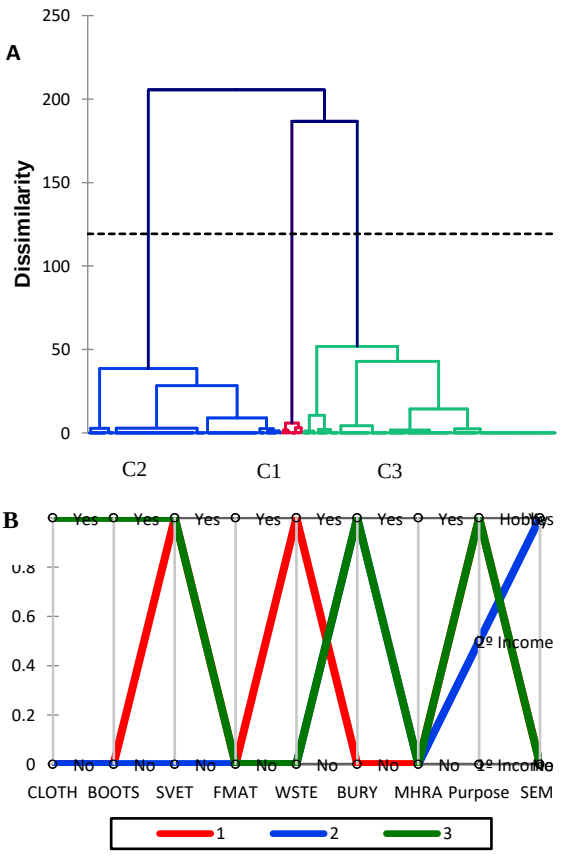

Fig. 9: Dendrogram generated by AHC (A) and parallel coordinate plot (B) of biosecurity practices related to disease prevention showing three clusters. C1- red, low biosecurity; C2-blue, medium biosecurity; C3-green, high biosecurity; BOOTS, using boots; BURY, burying dead pigs; CLOTH, farm clothing used; FMAT, sharing materials from other farms; SEM, attending seminar/s; SVET, segregate veterinary materials; WSTE, proper waste disposal.

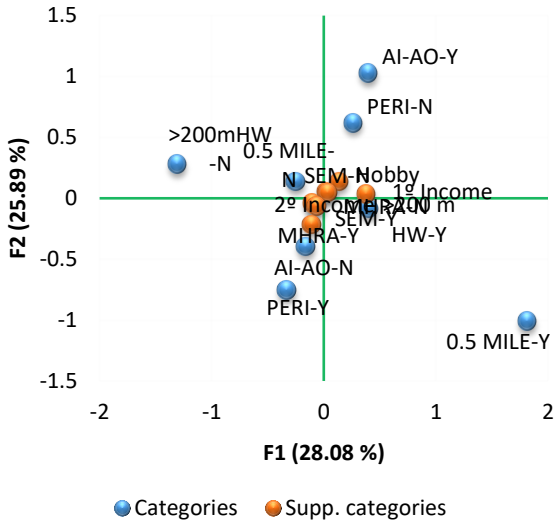

Fig. 10: Two-dimensional multiple-correspondence analysis solution of biosecurity practices related to restriction to outside environment. n=312; Y, yes; N, no; >200mHW, at least 200 m from main road; 0.5 MILE, at least half mile away; AI-AO, all in-all out; PERI, perimeter fence; SEM, attending seminar/s.

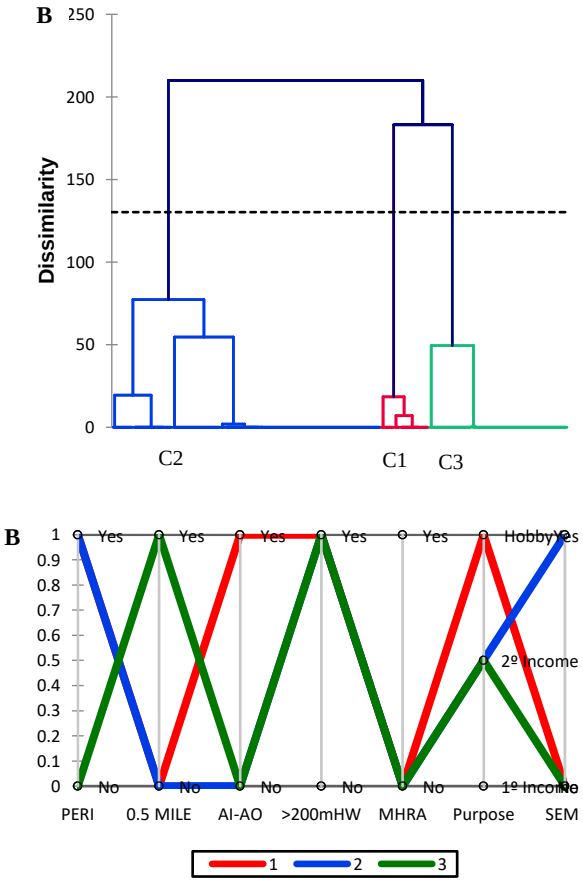

Fig. 11: Dendrogram generated by AHC (A) and parallel coordinate plot (B) of biosecurity practices related to restriction to outside environment showing four clusters. C1-red, high biosecurity; C2-blue, medium biosecurity; C3-green, low biosecurity; >200mHW, at least 200 meters from main road; 0.5 MILE, at least half mile away; AI-AO, all in-all out; PERI, perimeter fence; SEM, attending seminar/s.

Figure 6 provides the MCA solution for the variables regarding biosecurity practices against risks of disease entry. The total variance explained by the solution was 40.02% (24.20% by dimension 1 and 15.82% by dimension 2). Dimension 1 was influenced primarily by bird access (0.444), pet access (0.424), insect control (0.343), visitor access (0.153), and source of pigs from Negros Occidental (0.133). Dimension 2 was mainly influenced by rodent control (0.299), and presence of other livestock (0.073).

On the one hand, membership in MHRA appears to be associated with practices related to insect control, not raising other livestock, attendance in seminars and pig raising as a source of income. On the other hand, non-members of MHRA permit visitor entry to the farm anytime, raise pigs as either secondary source of income or hobby, do not attend seminars, do not practice both insect and rodent control and raise pigs along with other livestock. Three clusters were generated characterizing respondents' biosecurity practices against risks of diseases entry. Cluster 1 comprises 66.67% of respondents, cluster 2 at 19.55%, and cluster 3 at 13.78% (Figures 7A and 7B). Using PCP, these clusters are characterized as follow:

Cluster 1 (Red): Respondents of this group are mostly non-members of MHRA and raised pigs as a hobby. Neither visitors, birds and pet animals are inhibited from access to the piggery. No insect control is practiced but do have rodent control. Pig source exclusively comes from Negros Occidental and no other livestock is raised. Attendance to seminars is not practiced.

Cluster 2 (Blue): Respondents of this group are mostly non-members of MHRA and raised pigs as their primary source of income. While visitors are permitted free access to their piggery, control against entry of birds and pet animals is in place. Insect and rodent control are not practiced. The rest of practices were similar to Cluster 1.

Cluster 3 (Green): Respondents of this group are mostly non-members of MHRA and raised pigs as a hobby. Access by visitors, birds and pets is similar to Cluster 2. Insect and rodent control are in place. While pigs exclusively come from Negros Occidental, other livestock are also present.

Figure 8 shows the MCA solution for variables regarding biosecurity practices related to fomites and waste management. The total variance explained by the solution was 41.67% (24.06% by dimension 1 and 17.61% by dimension 2). Dimension 1 was influenced primarily by provision of personnel clothing (0.465), boots (0.381), and segregation veterinary supplies (0.233). Dimension 2 was mainly influenced by unrestricted sharing of farm materials (0.365), burying of dead pigs (0.215), and proper waste disposal (0.210). Membership in MHRA appears to be related to practices involving proper waste disposal, burying of dead pigs, attendance in seminars, and raising as secondary source of income. Whereas, raising pigs as a hobby, not attending seminars, no proper waste disposal, no personal clothing and segregation of veterinary supplies were associated with being a non-member of MHRA. Three clusters were generated characterizing biosecurity practices related to fomites and waste management (Figures 9A and 9B). Cluster 1 comprises 54.16% of the respondents, cluster 2 at 41.35%, and cluster 3 at 4.49%. Using PCP, these clusters are summarized as follow:

Cluster 1 (Red): Respondents of this group are mostly non-members of MHRA and raised pigs as a hobby. No personnel clothing and boots are provided but allow segregation of veterinary supplies. No sharing of farm materials to other piggery or *vice versa* is practiced. While farm wastes are properly disposed, burying their dead pigs and attendance to seminars are not practiced.

Cluster 2 (Blue): Respondents of this group are mostly non-members of MHRA and raised pigs as secondary source of income. Oher practices are similar to Cluster 2 except that burying of dead pigs and attendance to seminars are practiced.

Cluster 3 (Green): Respondents of this group are mostly non-members of MHRA and raised pigs as a hobby. Unlike in Clusters 1 and 2, personnel clothing and boots were provided. Disposal of dead pigs and attendance to pig raising seminar are practiced similar to Cluster 2.

Figure 10 provides the MCA solution for variables regarding biosecurity practices related to restricting contact with external environment. The total variance explained by the solution was 53.96% (28.08% for dimension 1 and 25.89% for dimension 2). Dimension 1 was influenced primarily by location being >200 meters away from the main road (highway, 0.528), and at least 500 meters away from other piggery (0.446). Dimension 2 was mainly influenced by provision of perimeter fence (0.467) and the practice of all-in-all out production system (0.407). It was observed that non-membership in the MHRA and raising pigs as a secondary source of income is associated with not practicing an all in-all-out system, providing perimeter fence, and piggery not situated at least half a mile away from other piggery. On the other hand, raising pigs as either a primary source of income or a hobby and membership in MHRA is associated with practices such as locating the piggery more than 200 meters away from the main road, non-provision of perimeter fence, and non-attendance to seminar. Three clusters were generated characterizing biosecurity practices related to restriction to external environment (Figures 11A and 11B). Cluster 1 comprises 58.97% of the respondents, cluster 2 at 30.45%, and cluster 3 at 10.58%. Using, PCP, these clusters are summarized as follow:

Cluster 1 (Red): Respondents of this group are mostly non-members of MHRA and raised pigs as a hobby. Perimeter fence is provided, the distance to other piggery is less than half mile away from other piggeries and is at least 200 meters away from the main road. All in-all out is practiced but respondents do not normally attend pig raising seminars.

Cluster 2 (Blue): Respondents of this group are mostly non-members of MHRA and raised pigs as a hobby. The other practices are similar to Cluster 2 except for attendance to pig raising seminar.

Cluster 3 (Green): Respondents of this group are mostly non-members of MHRA and raised pigs as a hobby. No perimeter fence is provided and is located at least 200 meters away from the main road. All in-all out is not practiced in the same way as attendance to seminars.

DISCUSSION

The profitability of swine production operation is greatly influenced by farm management practices; thus,

good management can result to better productivity. However, in the event of disease, farm losses can significantly result to financial strain on pig producers particularly those operating in small scale production. Using comprehensive MCA of biosecurity practices by smallholder pig raisers in Murcia, Negros Occidental, our study shows a number of potential areas that need improvement making such results both a challenge and an opportunity for better production outcome.

While swine management systems and practices greatly vary between different areas and individual pig producers, this is largely influenced by the size of operations, available land, market, capital, labor, and available feed among others (Ensminger and Parker, 1997). Moreover, between livestock species, different biosecurity standards and practices exist among different veterinary practitioners (Anderson, 2010). Strong implementation of biosecurity, whose end goal is to prevent entry of pathogens and or minimize the impact of endemic pathogens (Levis and Baker, 2011) can be quite challenging. In a study by Gunn *et al.* (2008) among cattle and sheep farms in Great Britain, the ability and willingness of famers, along with additional proof of efficacy and potential economic benefits play significant roles for better adoption of biosecurity measures.

On this study, we found that backyard pig producers raise pigs either as a source of income or a hobby and this orientation appeared to influence the biosecurity practices of pig owners. When it comes to disease prophylaxis in particular, deworming, quarantine and isolation of sick pigs do not appear to be paramount when the purpose of raising pigs is a hobby.

In the Philippines where many backyard pig operations depend on boars-for-hire servicing from one village to another (Lañada *et al.*, 2005), biosecurity measures become even more important. Apparently, a study by Simon-Grifé *et al.* (2013) in Spanish pig farms noted that biosecurity measures against disease introduction by breeding stock were not practiced on many farms. Entry by visitors and vehicles were also most important. In fact, small herds located in low pig density areas were found to have lower biosecurity measures than those by medium-size to large farms located in high pig density areas. In Belgium, at least 9.4% of pig herds were small, hobby herds that reported different biosecurity and management characteristics despite its industrialized level of production (Ribbens *et al.*, 2008).

Despite only 19.87% of the respondents were members of MHRA, membership in such association appears to support interest and awareness among pig raisers. Apparently, attendance to pig raising seminars is quite important for MHRA-member respondents and key biosecurity practices were applied. However, due to its limited number, this was not clearly demonstrated after AHC/PCP. Overall, backyard swine raisers of Murcia, Negros Occidental appear to deworm and disinfect regularly, bathe their pigs, provide pens and bury dead pigs. It has to be noted however that in the case of pig raising in the Philippines, a number of players can be involved interacting with pig farmers including on-farm veterinarians, private consultants, pharmaceutical company representatives, government veterinarians, livestock technicians among others which can influence management operations between small and commercial pig raisers (Alawneh *et al.*, 2014).

Conclusions

We have demonstrated different clusters of pig raisers characterizing the biosecurity practices of smallholder pig producers in Murcia, Negros Occidental. Basic biosecurity practices have been applied but there are still a number of areas needing improvement especially when the purpose of raising pigs is a hobby. Overall, membership to the MHRA is still limited but is encouraged to support dissemination and implementation of good biosecurity practices particularly in disease prophylaxis, control of risks against diseases entry and proper waste management.

Acknowledgments

The authors are particularly thankful to the assistance given by Prof. Eugene B. Lañada for his constructive comments and by Mr. Wilfredo Taño Andico Sr. for his expert guidance in the study area. This study is part of a thesis work (Andico, 2019) dedicated to the strong pig farmers of Murcia, Negros Occidental with the kind support of the Municipal Mayor and the Provincial Veterinary Office.

Authors contribution

Both authors have contributed equally to this work.

REFERENCES

Addinsoft, 2018. XLSTAT statistical and data analysis solution. https://www.xlstat.com. Boston, USA.

Alawneh JI, TS Barnes, C Parke, E Lapuz, E David, V Basinang, A Baluyut, E Villar, EL Lopez, and PJ Blackall, 2014. Description of the pig production systems, biosecurity practices and herd health providers in two provinces with high swine density in the Philippines. Prev Vet Med, 114: 73-87.

Anderson DE, 2010. Survey of biosecurity practices utilized by veterinarians working with farm animal species. Online Journal of Rural Research & Policy, 5: 1-13.

Andico WV, 2019. Farm Management and Biosecurity Practices of Backyard Pig Raisers in Murcia, Negros Occidental: A Multiple Correspondence Analysis. College of Veterinary Medicine, Visayas State University, ViSCA, Baybay City, Leyte, Philipines. Undergraduate Thesis

Ensminger, M., Parker, R., 1997. Swine Science 6th Edition, pg. 273. Danville, IL. Interstate Publishers, Inc.

Greencare MJ, 1984. Theory and Applications of Correspondence Analysis, Academic Press, London.

Gunn G, C Heffernan, M Hall, A McLeod, and M Hovi, 2008. Measuring and comparing constraints to improved biosecurity amongst GB farmers, veterinarians and the auxiliary industries. Prev Vet Med, 84: 310-323.

Lañada EB, J-AL Lee, SJ More, BS Cotiw-an, and AA Taveros, 2005. A longitudinal study of sows and boars raised by smallholder farmers in the Philippines. Prev Vet Med, 70: 95-113.

Levis DG, and RB Baker, 2011. Biosecurity of pigs and farm security, University of Nebraska--Lincoln, Extension.

Philippine Statistics Authority (PSA), 2018. Swine Situation Report, January - March 2018. Available at https://psa.gov.ph/sites/default/files/attachments/ird/specialrelease/SWINE%20final.pdf [Accessed April 11, 2019].

Ribbens S, J Dewulf, F Koenen, K Mintiens, L De Sadeleer, A de Kruif, and D Maes, 2008. A survey on biosecurity and management practices in Belgian pig herds. Prev Vet Med, 83: 228-241.

Simon-Grifé M, G Martín-Valls, M Vilar, I García-Bocanegra, M Martín, E Mateu, and J Casal, 2013. Biosecurity practices in Spanish pig herds: Perceptions of farmers and veterinarians of the most important biosecurity measures. Prev Vet Med, 110: 223-231.

Tenenhaus M, and FW Young, 1985. An analysis and synthesis of multiple correspondence analysis, optimal scaling, dual scaling, homogeneity analysis and other methods for quantifying categorical multivariate data. Psychometrika, 50: 91-119.

The Research Advisors. Sample Size Table, 2006. Availale at https://www.research-advisors.com/tools/SampleSize.htm

Whittemore CT, and I Kyriazakis, 2008. Whittemore's Science and Practice of Pig Production, John Wiley & Sons.