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Original Research Article

ASSESSMENT OF BIOSECURITY PRACTICES AND THEIR RELATIONSHIP WITH AFRICAN SWINE FEVER STATUS IN PIG FARMS IN LAGOS STATE (2020–2024)

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ABSTRACT

African swine fever (ASF) remains a major constraint to pig production, particularly in high-density production clusters such as Lagos State, Nigeria, despite increasing awareness of biosecurity measures. This study assessed biosecurity practices across three pig farm sites, compared component scores, evaluated their association with ASF status, and identified predictors of biosecurity performance in Lagos State between 2020 and 2024. A cross-sectional study was conducted among 358 pig farms in Oke-Aro and Gberigbe piggery estates using systematic sampling. Data were collected using a structured electronic questionnaire. Biosecurity was assessed across isolation, traffic control, and sanitation components using a binary scoring system. Farms were classified as having good (≥50%) or poor (<50%) biosecurity. ASF status was determined using polymerase chain reaction for a subset of farms, complemented by World Organisation for Animal Health standard clinical and epidemiological case definitions. Overall, 61.5% of farms had good biosecurity (mean score: 25.63 ± 5.56), with significant variation across sites ($p<0.001$). The ASF outbreak of 2020 was reported in 80.4% of farms, with the highest occurrence in Site B (90.1%). Farms in Site B (AOR=0.30, 95% CI: 0.17–0.53) and Site C (AOR=0.39, 95% CI: 0.20–0.76) were less likely to have good biosecurity compared to Site A. Larger herd size was associated with better biosecurity (AOR=2.09, 95% CI: 1.14–3.95). No significant association was observed between overall biosecurity level and ASF occurrence ($p=0.271$). Although biosecurity practices were moderately adequate, ASF remained widespread, suggesting that farm-level biosecurity alone is insufficient in high-density production systems. Strengthened regional control, surveillance, and farmer compliance were recommended.

Keywords: *African swine fever, biosecurity, epidemiology, pig farm, Lagos state, Nigeria*

INTRODUCTION

African Swine Fever (ASF) is a contagious and transboundary viral disease of domestic pigs and wild boars with serious implications for animal health, food security, and sustainable livestock production (FAO, 2000; Penrith & Vosloo, 2009). The disease remains endemic in many parts of sub-Saharan Africa, including Nigeria, where recurrent outbreaks continue to threaten pig production and farmer livelihoods (FAO, 2021; WOAH, 2023). In Nigeria, ASF has persisted since its first report in 1973, with recurrent

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outbreaks posing a major constraint to pig production (Awosanya *et al*., 2015a; Tizhe *et al*., 2020). The 2020 outbreak, particularly in Lagos State, resulted in substantial economic losses and disruption of livelihoods, while more recent outbreaks highlight the endemic nature of the disease and continued vulnerability of production systems. The sustainability of the Piggery Industry is undermined by the persistence of ASF outbreaks, despite increasing awareness and adoption of preventive measures (Fasina *et al*., 2022). Lagos State, being one of the major pig-producing areas in the country, with large piggery clusters such as Oke-Aro and Gberigbe characterized by high farm density, frequent animal movement, and close interaction between farms, enables conditions that favour rapid disease transmission. In the absence of effective treatment or widely available vaccines, ASF control relies primarily on strict biosecurity measures, including isolation, traffic control, and sanitation (Fasina *et al.*, 2012; Gallardo *et al.*, 2015). However, studies have shown that adoption of these practices among pig farmers remains inconsistent, thereby facilitating disease persistence and spread (Chenais *et al*., 2019; Dixon *et al*., 2020; Kouam *et al*., 2020). In theory, farms with higher levels of biosecurity are expected to have a lower risk of ASF infection. Awosanya *et al*. (2015) reported gaps in the adoption and enforcement of biosecurity practices among livestock farms, indicating that the presence of biosecurity measures does not necessarily translate into effective disease prevention. Similar observations have been reported in other low- and middle-income settings, where financial constraints, limited technical knowledge, and weak regulatory systems affect compliance (Dione *et al*., 2020). Furthermore, ASF transmission in endemic settings may be influenced by factors beyond individual farm control, including informal pig trade, contaminated feed, and human-mediated spread between farms (Costard *et al*., 2019; FAO, 2021). In densely populated piggery estates such as those found in Lagos State, these factors may reduce the effectiveness of farm-level biosecurity measures.

Despite the importance of biosecurity, Lagos State still uses grouped regional data for its ASF-biosecurity assessment, thus, with limited empirical data unique to it. This study, therefore, assessed the status of the 2020 ASF outbreak and evaluated biosecurity practices adopted by pig farmers in selected piggery estates in Lagos State between 2020 and 2024, to identify gaps in high-density production systems, inform sustainable disease control strategies, and policy formulation.

MATERIALS AND METHODS

STUDY AREA

The study was conducted in Oke-Aro (Old Site: Site A; New Site: Site B) and Gberigbe (Site C) piggery estates located in Agege and Ikorodu Local Government Areas of Lagos State, Nigeria. These estates represent the largest concentration of pig farms in the state and are major hubs of pig production. Established in 1990 and 2001, respectively, the estates collectively host over 3,000 farmers and an estimated one million pigs, according to records from the Lagos State Ministry of Agriculture and Food Systems (MAFS) (Figure I).

STUDY DESIGN AND POPULATION

A cross-sectional study design was employed, with the study population comprised of pig farm owners and/or managers whose farms had been operational for at least one year before the 2020 ASF outbreak.

SAMPLE SIZE AND SAMPLING TECHNIQUE

A total of 358 respondents were selected. Sample size was determined using the Thrusfield formula for cross-sectional studies (prevalence = 37%). Participants eligible were selected using systematic sampling based on road/plot arrangement within the piggery estates, ensuring spatial representation across the clusters, with proportionate allocation between the two estates at a farm-to-farmer ratio of 1:1. For laboratory confirmation of ASF, a subset of farms (n=89; approximately 25%) was selected using systematic sampling across the estates. Within selected farms, pigs were sampled by randomly selecting clinically affected pigs, apparently healthy pigs, and additional slaughtered pigs at abattoirs linked to the estates.

DATA COLLECTION

Data were collected using a structured questionnaire developed from established biosecurity frameworks (FAO and WOAH guidelines) and previous studies (Awosanya *et al*., 2015). The instrument captured information on farm demographics, management practices, biosecurity measures, and ASF outbreak history, focusing on isolation, traffic control, and sanitation components. The questionnaire was pre-tested on 20 pig farms outside the study area within similar production settings to assess clarity, relevance, and consistency. Feedback from the pretest was used to refine wording, simplify response options, and standardize interpretation. Face and content validity were established through expert review by at least three veterinary epidemiologists and field practitioners.

Data were collected through face-to-face interviews using an electronic questionnaire administered via Kobo Toolbox. Interviewer training and pretesting were conducted to minimize bias and ensure data quality.

Figure I: Map of Lagos State Showing Oke-Aro and Gberigbe Pig Estate Study Area in their respective Local Government Areas (LGAs)
(Source: Ogunleye *et al*., 2026, generated using QGIS 3.0x (Open Source Geospatial Foundation, 2025)

ASF CASE DEFINITION AND LABORATORY CONFIRMATION:

A confirmed African swine fever (ASF) case was defined by detection of the ASF virus genome in blood or tissue samples using Polymerase Chain Reaction (PCR) at the National Veterinary Research Institute (NVRI), Vom, Nigeria, in accordance with World Organisation for Animal Health (WOAH) standards (WOAH, 2023) (Figure II).

ASF status at the farm level was determined using a standardized outbreak investigation framework integrating laboratory diagnosis, epidemiological linkage, and clinical case definitions. A farm was classified as a probable ASF case when it exhibited rapid within-herd transmission, high mortality affecting multiple age groups, and occurrence within a confirmed outbreak period or epidemiological linkage to a PCR-confirmed infected farm. A suspected case was defined as the occurrence of at least one of the following clinical signs: sudden high mortality, fever (≥40.5°C), anorexia, weakness, cutaneous haemorrhages or cyanosis (ears, snout, and abdomen), diarrhoea, vomiting, respiratory distress, or abortions in sows, consistent with FAO and WOAH field guidance (FAO, 2021; WOAH, 2023).

A farm was classified as ASF-positive if it met either PCR confirmation or the probable case definition during the outbreak period. This combined diagnostic approach is consistent with established field epidemiological practice in resource-limited settings where complete laboratory coverage is not feasible and has been applied in previous ASF outbreak investigations (Chenais *et al*., 2019; Costard *et al*., 2019).

A subset of farms (n = 89) was subjected to laboratory confirmation. All samples were processed at NVRI, Vom, using PCR, and all tested positive for ASF virus. Molecular characterization identified ASF virus genotype II (ASFV II) (Figure 3), consistent with strains implicated in recent transboundary outbreaks and documented in Nigeria and other West African epidemic contexts (Gallardo *et al*., 2015; Dixon *et al*., 2020; WOAH, 2023).

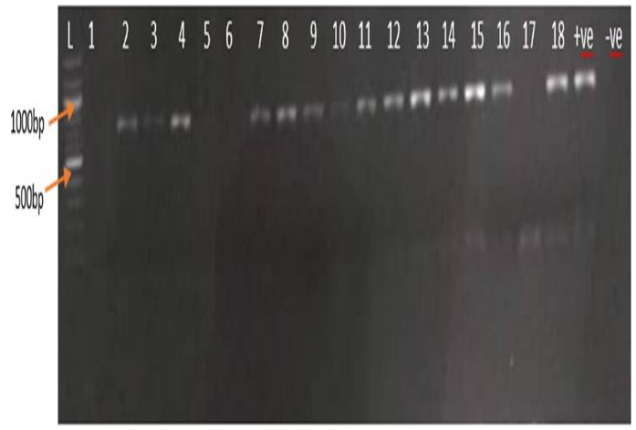

Figure II: Agar Gel Electrophoresis of ASFV PCR

Figure III: Phylogenetic Tree Molecular Structure of ASFV2 Products 1- 18 are ASF samples.

Phylogenetic tree, molecular testing and genomic study. The positive samples were amplified at 780bp structure, identifying the new ASFV genotype 2 isolated for the first time in Nigeria, from samples tested: [8]. (L): A 100 bp DNA marker (Qiagen®). (NVRI)

BIOSECURITY ASSESSMENT

Biosecurity practices were evaluated using a bimodal scoring system based on three components: isolation, traffic control, and sanitation. Each practice was assigned a binary score (presence = 1, absence = 0), and scores were summed to generate component and total biosecurity scores for each farm, while assuming equal importance of all biosecurity components. Scores were converted into percentages, with ≥50% classified as good biosecurity and <50% as poor biosecurity (Fasina *et al*., 2012; Kouam *et al*., 2020). The ≥50% cut off was adopted as a pragmatic operational threshold to distinguish relatively higher versus lower levels of biosecurity implementation. This approach has been used in similar studies assessing farm-level biosecurity in low- and middle-income settings, where standardized weighting systems are lacking and practices are highly heterogeneous (Mutua *et al*., 2019; Dione *et al*., 2020). Additionally, the use of a midpoint threshold allows simplified interpretation of composite scores, comparability across farms and study sites, and alignment with previous epidemiological studies that dichotomize composite indices for regression analysis (Laanen *et al*., 2014; Nöremark *et al*., 2016).

DATA ANALYSIS

Data were analyzed using [SPSS/Stata/R]. Descriptive statistics were summarized as frequencies, percentages, means, and standard deviations. Differences in mean biosecurity scores across sites were assessed using one-way ANOVA, while component-level differences were evaluated using the Kruskal–Wallis test. Associations between categorical variables were examined using chi-square tests. Variables with $p<0.20$ in bivariate analysis were included in multivariable logistic regression models to identify independent predictors. Results were reported as odds ratios (OR), adjusted odds ratios (AOR), 95% confidence intervals (CI), and p-values, with statistical significance set at $p<0.05$. We addressed potential confounding during model development by including variables with $p < 0.20$ at the bivariate level and those considered biologically plausible, such as herd size, farm site, and farmer characteristics. Adjusted estimates from the multivariable logistic regression were compared with crude estimates to assess the presence of confounding. Model adequacy was thus evaluated using standard diagnostic procedures. Goodness-of-fit was assessed using the Hosmer–Lemeshow test, while multicollinearity among independent variables was examined using variance inflation factors (VIF). Summarily, no evidence of problematic multicollinearity was observed, but overall, the final model demonstrated acceptable fit and stability, supporting the validity of the reported associations.

ETHICAL CONSIDERATION

Ethical approval was obtained from the Lagos State Ministry of Agriculture and Food Systems, Planning and Research Ethics Department, and the Veterinary Services Department (Ref: MOA/PPD/574) (Figure IV). Informed consent was obtained from all participants while ensuring confidentiality.

RESULTS

SOCIO-DEMOGRAPHIC CHARACTERISTICS OF RESPONDENTS

The socio- demographic characteristics of pig farmers across the three study sites (n=358), reveals majority of respondents were farm owners (78.2%), and 54.2%) were males. The mean age was 49.32 ± 10.80 years. Most had >5years of farming experience (70.9%) and at least a formal secondary education (91.6%). Only 14.2% had formal training in pig farming, although a large proportion (86.6%) reported informal training.

FARM MANAGEMENT PRACTICES

Most farms operated at a medium scale (78.2%), with widespread use of commercial feed (93.0%). However, some risk practices persisted, including use of blood meal and untreated kitchen waste. The majority of farms relied on paid labour (80.2%) and operated with small workforce sizes (≤5 workers).

BIOSECURITY SCORES AND DISTRIBUTION

The overall mean biosecurity score was 25.63 ± 5.56 (range: 7.50–43.00). Mean scores across each component was Isolation: 8.56 ± 3.03, Traffic control: 5.73 ± 2.22, and Sanitation: 11.33 ± 2.32. While Biosecurity scores differed significantly across sites ($F=16.33$, $p<0.001$), with Site A having the highest scores.

TABLE I: MEAN BIOSECURITY SCORES BY SITE

Site	N	Mean ± SD	95% CI	Min-Max
A	239	26.70 ± 5.07	26.05–27.35	11.5–43.0
B	71	22.72 ± 5.95	21.31–24.13	7.5–40.5
C	48	24.58 ± 5.64	22.94–26.22	13.5–35.5

ANOVA: $F=16.33$, $p<0.001$

BIOSECURITY COMPONENT COMPARISON

Significant differences were observed across all biosecurity components (P<0,001).

TABLE II: BIOSECURITY COMPONENT SCORES ACROSS SITES (KRUSKAL-WALLIS TEST)

Component	Site A Mean	Site B Mean	Site C Mean	p-value
Isolation	8.94	7.77	7.84	0.001
Traffic Control	5.93	4.79	6.13	<0.001
Sanitation	11.82	10.16	10.61	<0.001

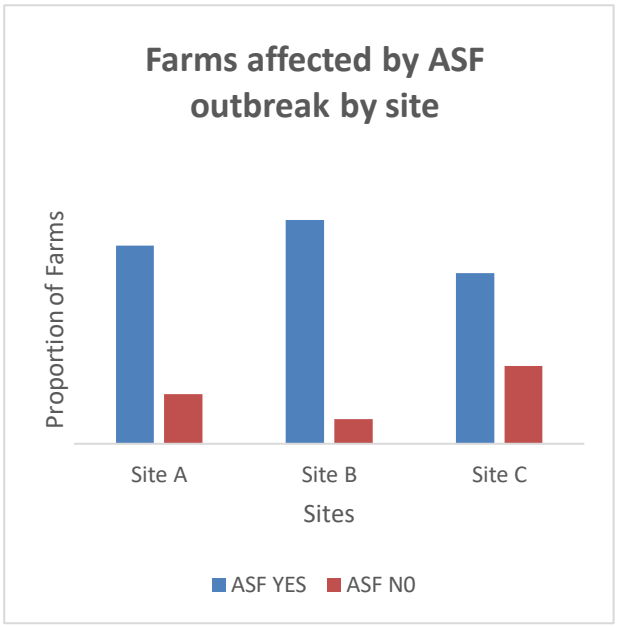

Figure IV: Proportion of farms affected by the ASF outbreak by site

ASF OUTBREAK EXPERIENCE

ASF was reported in 2020 by 80.4% of the respondents, with the highest occurrence in Site B (90.1%).

FACTORS ASSOCIATED WITH BIOSECURITY COMPONENTS

Multivariable analysis showed that Farms in Site B had significantly lower odds of good biosecurity across components. Larger herd size (>100 pigs) increased the likelihood of good biosecurity. Male respondents were less likely to implement good sanitation.

TABLE III: PREDICTOR OF BIOSECURITY COMPONENTS (ADJUSTED ODDS RATIOS)

Variable	Outcome	AOR	95% CI	P-value
Site B vs A	Isolation	0.39	0.20-0.72	0.004
Herd size>100	Isolation	2.04	1.17-3.55	0.011
Site B vs A	Sanitation	0.22	0.10-0.44	<0.001
Male vs Female	Sanitation	0.50	0.25-0.96	0.040

PREDICTORS OF OVERALL BIOSECURITY

Overall, 61.5% of farms had good biosecurity practices. After adjustment, Site B (AOR=0.30, p<0.001) and Site C (AOR=0.39, p=0.005) had lower odds. Herd size >100 increased odds
(AOR=2.09, p=0.012) and Male gender reduced odds (AOR=0.63, p=0.048).

TABLE IV: PREDICTORS OF GOOD BIOSECURITY

Variable	AOR	95% CI	P-value
Site B vs A	0.30	0.17-0.53	<0.001
Site C vs A	0.39	0.20-0.76	0.005
Herd size >100	2.09	1.14-3.95	0.012

RELATIONSHIP BETWEEN BIOSECURITY AND ASF OCCURRENCE

There was no statistically significant association found between biosecurity status and ASF outbreak experience (p=0.271). Thus, differences were not statistically significant (p=0.271).

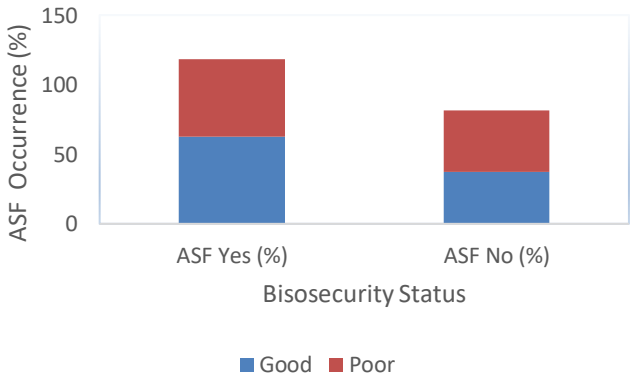

Figure V: Relationship between Biosecurity Status and ASF Occurrence

DISCUSSION

This study evaluated the biosecurity practices and their relationship with African swine fever (ASF) status in pig farms within Lagos State, Nigeria, from 2020 to 2024. The findings revealed generally moderate to high levels of reported biosecurity practices, significant variation across farm sites, and a high prevalence of ASF outbreak experience. However, no statistically significant association was observed between overall biosecurity scores and ASF occurrence, an outcome that warrants careful interpretation within the context of endemic disease dynamics and field-based reporting limitations, with the high proportion of farms reporting ASF outbreaks in Nigeria. Similar patterns have been reported in previous studies in West Africa, where ASF continues to circulate despite farmer awareness of preventive measures (Penrith *et al.*, 2020; Fasina *et al*., 2022). The high-density structure of piggery estates such as Oke-Aro and Gberigbe likely facilitates rapid transmission through direct and indirect contacts, reinforcing the endemic nature of infection.

Biosecurity assessment showed that although many farms reported the presence of basic control measures, implementation was uneven across components and sites. Site A consistently recorded higher biosecurity scores compared to Sites B and C, suggesting possible differences in farm organization, enforcement, or access to veterinary support. This aligns with findings by Awosanya *et al.* (2015), who reported that biosecurity practices in Nigerian livestock systems are often inconsistently applied, with significant gaps between knowledge and practice. Despite these variations in biosecurity levels, no significant association was found between biosecurity score and ASF occurrence. This finding appears counterintuitive but is not uncommon in endemic livestock systems. Similar observations have been reported in ASF epidemiological studies in Eastern Europe and parts of Africa, where farm-level biosecurity alone did not significantly predict infection risk (Lange *et al*., 2019; Bellini *et al*., 2021). One plausible explanation is that in high-density production environments, external transmission pathways may override farm-level interventions.

ASF is known to be transmitted through multiple routes, including contaminated pork products, fomites, swill feeding, and human-mediated spread via movement of workers, traders, and equipment (Costard *et al.*, 2019; Chenais *et al*., 2019). In such contexts, even farms with relatively good internal biosecurity may remain exposed to infection due to external breaches in the production network. This may explain the observed paradox of relatively high biosecurity scores coexisting with high ASF occurrence. Another important consideration is the limitation of self-reported biosecurity data.

As noted in previous studies, self-assessment of farm practices is subject to social desirability bias, leading to overestimation of compliance (Dione *et al*., 2020). Farmers may report practices as being implemented even when they are inconsistently applied in reality. This misclassification may attenuate true associations between biosecurity and disease occurrence.

Additionally, ASF status in this study was determined using a combination of PCR-confirmed cases and standardized case definitions based on clinical and epidemiological signs. While PCR confirmation strengthens diagnostic validity, reliance on case definitions for non-sampled farms may introduce classification bias. However, this approach is commonly used in field epidemiology where full laboratory coverage is not feasible (FAO, 2021; WOAH, 2023).

The finding that larger herd size was associated with better biosecurity practices is consistent with previous studies, which suggest that commercial-scale farms are more likely to invest in structured management systems and controlled access measures (Laanen *et al*., 2014). Similarly, site-level differences in biosecurity suggest that structural and environmental factors play an important role in determining biosecurity implementation, beyond individual farmer characteristics. The study revealed training, particularly informal training, showed variable associations with biosecurity components. This supports the observation by Awosanya *et al*. (2015) that while training improves awareness, its translation into consistent practice may be limited without enforcement mechanisms and continuous extension support.

Overall, the lack of association between biosecurity and ASF occurrence in this study does not imply that biosecurity is ineffective. Rather, it highlights the complexity of ASF epidemiology in densely populated pig production systems, where disease transmission is influenced by a combination of farm-level, network-level, and environmental factors. Similar conclusions have been drawn in studies from Europe and Asia, where control of ASF required coordinated regional biosecurity measures rather than isolated farm-level interventions (EFSA, 2020; Bellini *et al*., 2021). These findings underscore the need for a more integrated ASF control strategy in Nigeria that goes beyond individual farm biosecurity. Strengthening movement control, improving surveillance at pig trade points, regulating feed sources, and enhancing farmer education on practical biosecurity implementation are likely to yield more sustainable disease control outcomes.

LIMITATIONS

A major limitation of this study was recall bias, rather than misclassification, and the reliance on a cross-sectional design, which limits causal inference. Additionally, the use of a 50% cut off for biosecurity classification, while consistent with similar studies, may oversimplify the complexity of biosecurity practices. Future research should consider weighted scoring systems and longitudinal designs to better capture dynamic risk relationships. Despite these limitations, this study provides important evidence from one of the largest pig production clusters in Nigeria and contributes to the ongoing discussion on the effectiveness of biosecurity in endemic ASF settings.

CONCLUSION

This study assessed biosecurity practices and their relationship with African swine fever (ASF) occurrence among pig farms in major pig production clusters in Lagos State, Nigeria. The findings showed that although many farms reported moderate to good levels of biosecurity practices, ASF remains highly prevalent across the study area. No significant association was observed between overall biosecurity scores and ASF occurrence. The results suggest that in high-density pig production systems, farm-level biosecurity alone may not be sufficient to prevent ASF transmission. Multiple interacting factors, including uncontrolled animal movement, informal trade networks, potential contamination of feed sources, and human-mediated transmission pathways, likely influence the persistence of ASF in the study area. Therefore, ASF control in such settings requires a broader, system-based approach rather than reliance on individual farm biosecurity measures alone.

RECOMMENDATIONS

We therefore make recommendations for strengthening of regional disease control systems, improved surveillance and diagnostic capacity, targeted farmer training and extension services, regulation/policies on feed and waste practices, infrastructure and estate-level biosecurity enforcement and further research through longitudinal studies for better understanding of ASF transmission dynamics, thereby evaluating the effectiveness of biosecurity interventions over time in high-density pig production systems.

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CONFLICT OF INTEREST:

The authors declare no conflict of interest, financial or otherwise, associated with this manuscript.

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