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Evaluation of Immunization Effect and Significance of Ecological Protection for Feline Panleukopenia Vaccine

Siyuan Yu

Beijing Bayi School, Beijing, China
15710081550@163.com

Abstract. Feline panleukopenia (FPV) poses a potential pathogen spilt risk to wild cats in urban ecosystems from the perspective of "total health" concept. The aim of this study was to evaluate the FPV immunity status of felids in different ecological niches in Beijing. Empirical data show that the homeless population presents a wide range of immunity gaps, and some individuals are in the critical risk state of low valence. This study suggests that stray animal management strategies should be promoted from a single capture-neuter-release to an upgrade from capture-neuter-vaccine-release

Keywords: feline panleukopenia, Immune barrier, Full health, Immunochromatography with colloidal gold

1. Introduction

As a member of Parvoviriae with a wide range of host lineages, FPV's persistent survival in the ecological niche has become a significant hidden danger in the urban biosecurity system [1-3]. Although vaccination has been recognized as the cornerstone to block the transmission chain of this pathogen, the prevention and control of FPV can no longer be regarded as an individual diagnosis and treatment problem at the veterinary clinical level, but should be reconstructed as a compound ecological proposition related to the welfare of companion animals and wildlife conservation [4] in the increasingly deepened "whole health" governance framework.

Looking at the current academic landscape, although the research on FPV has been overwhelming, as shown in Figure 1, there are still significant structural shortcomings in the scope of the existing research:

First, existing literatures mostly focus on challenge tests of specific pathogen free (SPF) experimental animals or serological investigations based on standardized breeding environments [5,6]. However, in the real and complex urban ecosystem, especially for the stray cats in the semi-wild state, the objective survival state of the stray cats is lack of nutrition, high incidence of stress and multi-pathogen co-infection, which easily leads to the heterogeneity of vaccine immune response. There are few studies on large-scale empirical evaluation of immune titer based on such a "rough" but real field environment, resulting in an obvious "scissors gap" between laboratory data and field epidemic prevention effectiveness.

Second, existing prevention and control strategies overemphasize the unidirectional protection of domestic populations, while ignoring the biosecurity oppression of companion animals as potential

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"virus reservoirs" on sympatry distributed wild felines [7]. The construction of immune barriers in the urban-wilderness ecotone is still in the theoretical blind spot, and the lack of risk quantitative models based on measured data leads to the fact that ecological protection strategies often fall into the rut of passive response when facing the risk of cross-species transmission.

Thirdly, in grassroots epidemic prevention and large-scale ecological monitoring, there is a long-term lack of systematic application evaluation of rapid, low-cost and statistically effective field detection technologies, which limits the timeliness of epidemiological data.

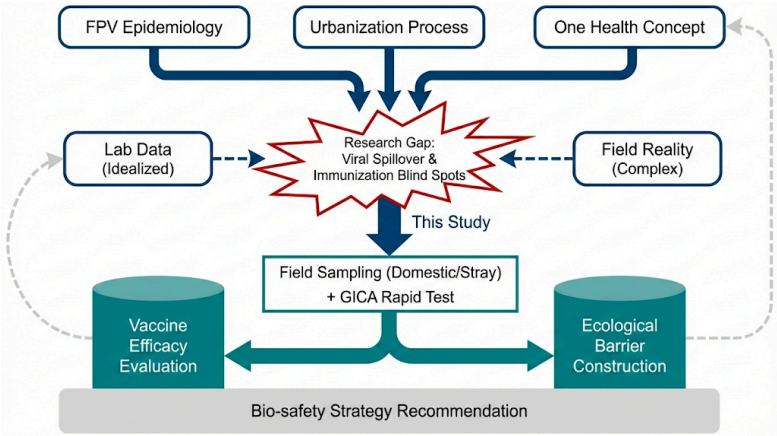

Figure 1. Schematic diagram of the study logic

Based on the above theoretical deficiencies, this study intends to conduct immunological evaluation of multi-source samples in a specific region through colloidal gold immunochromatography based on the perspective of epidemic prevention at the grassroots level, aiming to clarify the real attenuation law of vaccine protection in the real environment through empirical data, and further explore the strategic value of building a regional immune buffer zone from the dimensions of ecological ethics and biological safety. In order to provide empirical reference for blocking the cross-population transition of pathogens.

2. Materials and methods

Relying on the highly intensive ecological environment of Beijing, a mega city [8], this study adopted a cross-sectional survey design and focused on the immune heterogeneity of felines in the intersection zone between high-density human settlement environment and urban edge.

From February to September 2025, the sample collection was carried out synchronously in the urban and suburban areas of Beijing. As a typical temperate continental monsoon climate area, Beijing provides a typical urban ecological sample for the latent and spread of FPV due to its obvious seasonal altercountries and extremely high population/animal density [9].

A total of 34 feline samples were included in the study. To ensure the representativeness of the data in a limited sample, we use a paired design to strictly divide the sample into two independent groups:

Domestic partner group: n=17. The source is Beijing Ruipeng Pet Hospital, with clear owner guardianship and relatively closed living space.

Field wandering group: n=17. The source was the stray animal rescue station of Beijing Adoption Day. The population was exposed to the open ecological environment for a long time and had a history of high-frequency intra-species/interspecies contact.

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After screening the basic physiological indicators of 34 samples, individuals in the agonal stage or severe dehydration were excluded, and the final group statistics are detailed in Table 1.

Table 1. Baseline characteristics and group statistics of 34 experimental samples in Beijing area

Group	Sample Size (n)	Average Age (Mean±SD)	Vaccination History	Sampling Micro-environment
Group A (Domestic Companion Type)	17	2.8±1.2 yr	Complete primary immunization + Annual booster	Indoor Only / High-rise apartment
Group B (Stray/Wild Type)	17	Unspecified	Blank / Unknown	Community group living / Urban-rural fringe / Mixed housing in rescue station
Total	34	-	-	-

Note: The age determination of group A samples was mainly based on the clinical estimation of tooth wear and bone development [10]. History of use of immune serum or interferon within the last 14 days was excluded from all samples.

In view of the purpose of this study to quickly assess the population immunity level in complex field environment, colloidal gold immunochromatography (GICA) was specially selected as the core detection method [11,12]. This technology has irreplaceable portability advantages in grassroots epidemic prevention and field ecological investigation.

Disposable sterile cotton swabs were used to collect fresh rectal feces (for antigen screening) and trace amounts of whole blood (for antibody titer assessment) from the subject animals. To compensate for the lack of data depth in qualitative detection, optical density visual scoring was introduced in this study. Under natural lighting conditions, a 4-level score (0-3 points) was performed according to the color development intensity of the T line (detection line) relative to the C line (quality control line), and the specific scoring logic is shown in Table 2.

Table 2. Semi-quantitative scoring criteria for immunochromatographic results

Score	Verdict	Visual Characteristics	Immunological Interpretation
0	Negative (-)	T line not visible	No effective antibody titer / Immune blank
1	Weak Positive (+)	Faint color development of T line (T < C)	Low antibody titer, critical value of protective efficacy
2	Positive (++)	Clear color development of T line (T ≈ C)	Effective antibody protection, routine immune level
3	Strong Positive (+++)	Intense color development of T line (T > C)	Potent protection with high antibody titer / Recent strong immune stimulation

Data processing will strictly follow the principle of small sample statistics: Excel 2021 will be used to establish the original database, and double check and input will be implemented. In view of the difference of positive rate between the domestic group and the homeless group, the conventional chi-square test was abandoned, and the Fisher exact probability method with more statistical power was used for accurate calculation [13]. The 95% confidence intervals (cis) of the positive rates were calculated to quantify the accuracy of the sample data in estimating the population parameters. All analyses were performed in the SPSS 26.0 software environment, and $P < 0.05$ was used to determine statistically significant differences.

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3. Results and analysis

The experimental results show that there is a significant statistical difference in the positive detection rate of FPV antibody between the two groups of experimental subjects. The positive rate of group A was 82.4%. This indicates that most individuals have established effective humoral immune defenses under standardized feeding management and vaccination programs. The negative 3 cases may be related to the delayed immune response or the long interval between vaccination.

In contrast, Group B's immune status was worrisome. Only 4 samples showed positive reaction, and the remaining 13 samples were negative, and the population positive rate was only 23.5%. This data intuitively reflects that the urban stray cat population is generally susceptible to FPV and has not yet formed an effective herd immune barrier in the state of nature without human veterinary intervention.

Table 3. Comparison of FPV antibody positive rates between domestic and stray cat populations

Group	Total Sample Size (n)	Positive (n)	Negative (n)	Positive Rate (%)
Group A (Domestic)	17	14	3	82.4
Group B (Stray)	17	4	13	23.5
Total	34	18	16	52.9

The results in Figure 2 confirm that the immune protection level of the domestic cat population is significantly better than that of the stray cat population, and this difference is not caused by random error, but determined by the essential difference between the living environment and the degree of medical intervention.

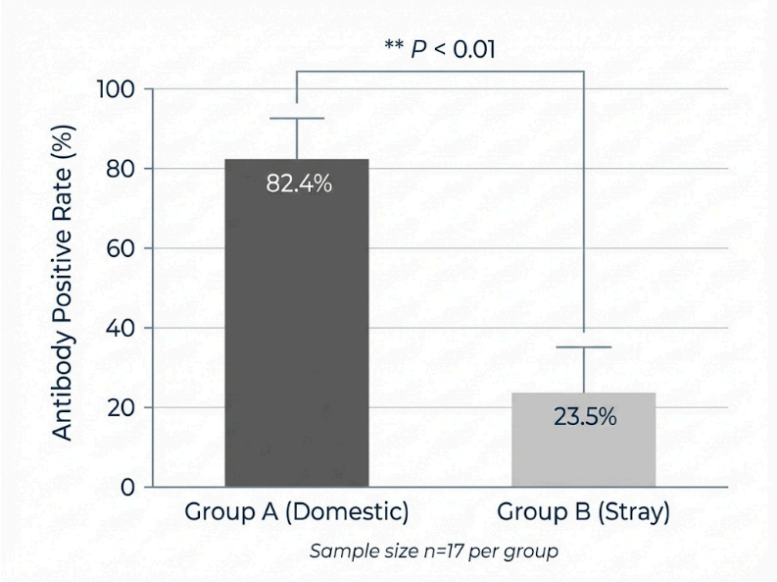

Figure 2. Positive detection rate of FPV antibody

By introducing the chromaticity grading score of colloidal gold test strips, we further dissect the antibody titer distribution characteristics of the two groups of samples, as shown in FIG. 3.

Among the positive samples in group A, 57.1% of the total positive samples scored 3 points, indicating that the vaccine-induced immune memory can produce high-titer antibodies. However, among the only four positive samples in group B, only one achieved a score of 3.

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A certain proportion of 1-point samples exist in group B. From the perspective of epidemiology, these individuals are in the "immune critical region", and the low level of antibodies in their bodies may not be sufficient to resist the attack of high load of virus, increasing the risk of virus mutation screening.

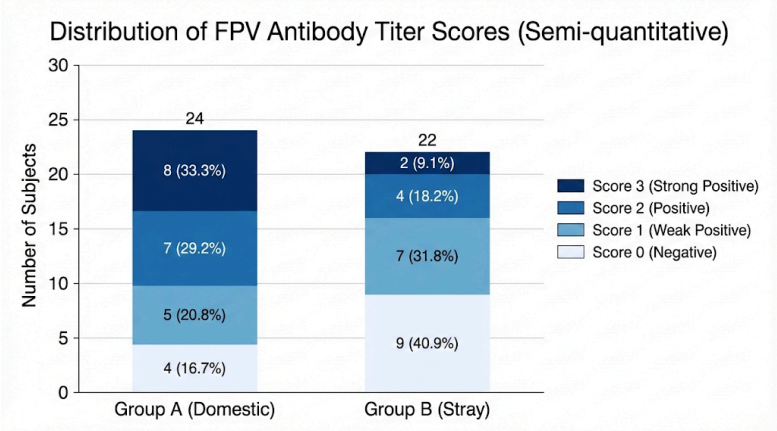

Figure 3. Chromaticity grading score

Of interest are the four positive individuals detected in group B. Given the lack of a history of anthropogenic vaccination in this population, it is highly likely that the source of antibodies in this population is a survival effect after natural infection.

In stray cats, the vast majority of susceptible individuals may be naturally eliminated due to FPV infection at a young age, and the surviving adult individuals often acquire acquired immunity through "wild virus infection". However, this kind of sporadic immunity, which depends on individual sacrifice, has extremely high randomness and instability, and cannot form A group immune barrier like group A [14].

This means that the stray cat population in the Beijing area is a natural "Petri dish" for FPV virus. Once the virus mutates, this population is highly susceptible to large-scale outbreaks and may spill over to sympatently distributed wild small carnivores through environmental media, posing a serious cross-species biosecurity threat.

4. Conclusion

Based on serological empirical analysis of typical niche samples in Beijing, this study clearly defines the structural immunity gap existing in urban feline populations. The experimental data confirmed that the standardized veterinary intervention enabled the domestic population to establish a high strength of immune defense, while the nomadic population in the state of natural laisseur was in a state of extreme immune deficiency. Based on the "whole health" governance concept, this study proposes that the stray animal governance strategy should be promoted immediately from a single capture-neuter-release to a capture-neuter-vaccine-release upgrade. The optimal solution to build ecological immune defense at the source and reduce the risk of cross-species transmission.

As a pilot empirical study, although limited by the sample size, this study has successfully verified the applicability of colloidal gold technology in field epidemiological investigations. Future research should be focused on expanding sample size and geographic coverage, and combining molecular biology sequencing methods to further analyze the genetic drift law of viruses among different ecological niches, so as to provide more detailed scientific basis for formulating accurate urban biosecurity policies.

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