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Epidemiology of canine parvovirus infection in and around Pantnagar, Uttarakhand: A retrospective study

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Abstract
In India, Canine Parvovirus Infection is an endemic viral disease-causing severe gastroenteritis and significant numbers of deaths in puppies, even in vaccinated populations. A retrospective study was conducted between June, 2021 and June, 2022 in and around Pantnagar, Uttarakhand, in which cases of gastro-enteritis were screened for canine parvovirus infection. A total of 258 cases out of 627 cases presented for gastro-enteritis were found to be positive for canine parvovirus based on Rapid Antigen Tests and Polymerase Chain Reaction with a prevalence rate of 41.15%. Data associated with factors such as age, breed, sex, season, immunisation and relocation stress were recorded. Mongrels were found to be the most affected among various breeds, with a prevalence rate of 51.16%, followed by the exotic breed Labrador retriever (9.68%). Males (63.57%) were more found to be affected more than females (34.43%). As for age, prevalence was higher in the age group of 3-6 months (43.40%), followed by less than 3 months of age (31.40%) respectively. Considering other risk factors such as season, vaccination status and relocation stress, prevalence was seen to be higher in to be higher comparatively in spring (33.33%) and winter (29.07%); also, higher prevalence in non-vaccinated (63.13%) and about 25.19% of the animals which were relocated recently were found to be infected with canine parvovirus.

Keywords: Parvovirus, immunisation, variants, puppies, relocation, spring

Introduction
Canine Parvovirus is one of the commonly encountered viral agents causing severe gastro-enteritis in puppies in current times. Canine parvovirus (CPV) is a member of the family Parvoviridae, sub-family Parvovirinae and genus Protoparvovirus (Khatri *et al.*, 2017) +. Affection with CPV is believed to be among the leading causes of morbidity and mortality in young dogs across the globe (Bargujar *et al.*, 2011) [5]. Canine Parvovirus (CPV) is a linear, non-enveloped virus containing approximately 5323 bases of single stranded negative-sense DNA. Despite being a DNA virus, the genomic substitution rate of CPV is approximately 10^{-4} per site per year, which is alike RNA viruses (Tsao *et al.*, 1991; Shackelton *et al.*, 2005) [38, 39]. The canine parvovirus-1 (CPV-1), commonly known as the minute virus of canines, was first identified as the cause of respiratory and gastrointestinal infections in dogs in the late 1960s. Ten years later, a mutation in CPV-1 produced Canine Parvovirus-2 (CPV-2), a fundamentally different variant type. This mutation caused the first pandemic outbreak in both young and older dogs that had previously been immune to CPV. Since then, it has become well-established as a global gastrointestinal disease of dogs with high morbidity (100%) and mortality up to 10% (Lamm and Rezabek, 2008) [15]. The structural protein VP2, which is the major capsid protein that determines viral tissue tropism and host range, is the virus's major antigenic protein (Parrish *et al.*, 1988; Zhou *et al.*, 2017) [22, 40]. CPV-2 is widespread and can survive in the environment for more than a year, exposing susceptible dogs to infected faeces, vomitus, or fomites. Because the virus is shed in faeces, the traditional mode of transmission is faeco-oral route. Following natural or experimental exposure, the incubation period of CPV ranges from 4 to 14 days (McCaw and Hoskins, 2006; Sykes, 2014) [17, 35]. Lack of protective immunity, intestinal parasites, overcrowding, unsanitary compromises, overcrowding, and stressful environmental conditions all predispose puppies to parvoviral infection (Hong *et al.*, 2007) [11]. Geographic variations influence breed predisposition and seasonal prevalence of the disease (Al-hosary, 2000) [1]. The virus generally replicates in sites such as the small intestine, bone marrow, and lymphatic tissues where the existing cells have a high proliferation rate. (Goddard *et al.*, 2008; Sime *et al.*, 2015) [9, 32]. The disease is distinguished by two prominent clinical forms namely gastro-enteritis with vomiting and diarrhoea in dogs aged less than one

year, and myocarditis with subsequent heart failure in puppies aged less than eight weeks. Virus replication results in damage to intestinal mucosal lining, villous atrophy, resulting in malabsorption, profuse diarrhoea and vomiting, severe dehydration/hypovolemia, and metabolic acidosis (or alkalosis) (Simpson and Birnbaum, 2006) [29]. Septicaemia, endotoxemia, systemic inflammatory response syndrome (SIRS), hypercoagulability, multiorgan failure, and mortality can all be triggered as a result of bacterial translocation via the damaged intestinal mucosa. (Appel *et al.,* 2000; Kalli *et al.,* 2010) [2, 12]. Treatment of CPV infection in dogs focuses mainly on stabilizing fluid and electrolyte concentrations, preventing secondary bacterial infections, and controlling clinical signs and symptoms. Survival rates depend on how quickly CPV-2 is diagnosed, the age of the animal and introduction of aggressive therapy (Mylonakis *et al.,* 2016) [19]. Vaccination of dogs with attenuated or modified live vaccines is used to prevent the disease (Sayed-Ahmed *et al.*, 2021) [27]. In order to estimate the prevalence and potential risk factors of parvovirus infection in and around Pantnagar, Uttarakhand, a retrospective study was conducted.

Materials and Methods

For a one-year time period from June 2021 till June 2022, an epidemiologic study was conducted at Veterinary Clinical Complex, College of Veterinary and Animal Sciences, G. B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand. Animals were initially screened on the basis of history and clinical signs such as vomition, diarrhoea, anorexia, fever, tachycardia, weakness and depression. During the period of study, a total of 627 cases of gastroenteritis were reported out of which 258 were found to be positive for Canine Parvovirus Infection with initial screening using Rapid Antigen Test (RAT) and subsequent confirmation by Polymerase Chain Reaction (PCR). For statistical analysis, data were evaluated using MS Excel Office 365 and prevalence was assessed as percentage of total cases.

Results and Discussion

The overall prevalence of canine parvovirus in the above-mentioned time period was found to be 258/627 cases (41.15%) (Table 1) (Figure1). Similar findings were noted by Behera *et al.,* (2015) [6] and Singh *et al*., (2013) [33] who reported similar higher prevalence of 40.85% and 63% respectively in Odisha and Uttar Pradesh during a one-year period study. The variation in the prevalence of CPV might be attributed to varied diagnostic tests, wide variation in the number of samples, differences in study period, geographical area variations; thus, comparison in this regard would be less beneficial (Khare *et al.,* 2019) [13].

Breed wise, prevalence of CPV infection were found to be maximum in mongrels i.e., 51.16% (132/258), which is in accordance with findings by Behera *et al.,* (2015) [6] and Sayed-Ahmed *et al*., (2021) [27] who reported 34.48% and 48.5% respectively which might be due to higher density of mongrels in the study area, they are inherently of wandering nature; close proximity to each other increases the chances of infection spread; due to lack of awareness and responsibility, vaccination schedules are not rightly followed by mongrel dog owners thus pre-disposing them to the disease (Behera *et al.,* 2015) [6] (Table 2) (Figure 2). As of exotic breeds, Labrador retriever showed the highest prevalence rate (9.68%), followed by German Shepherd (8.53%) and Rottweiler (8.14%) respectively which is concurrent with findings of Behera *et al.,* (2015) [6] (Table2) (Figure2). As stated by Archana *et al.,* (2010) [4] and Khare *et al*., (2019) [13] no specific remarks can be made on breed susceptibility as the population density of breeds differ from one geographical location to another. Ling *et al.,* (2012) [16] reported that Doberman, Rottweiler, and German shepherd dogs were found to be more prone to CPV infection than other breeds which might be due to the fact that these breeds have inherited immunodeficiency and hence are more susceptible.

Age wise study resulted in a higher prevalence in dogs in age groups of 3- 6 months (43.41%) followed by less than 3 months of age (31.40%), comparatively lower incidence in 6-12 months age group (20.93%) and minimal in age group more than 12 months of age (4.26%); the findings correlated with Behera *et al.,* (2015) [6] and Srinivas *et al*., (2013) [31] (Table 2) (Figure 3). Higher incidence of CPV below 6 months age might be due to two reasons; one being the greater affinity of the virus towards newly dividing cells and the other in spite of vaccination, maternal antibodies in the immediate perinatal period could interfere with the ability of vaccines to induce immunity thus causing vaccination failure and making the animal susceptible (Rashid *et al*., 2009) [24]. Also, after 3 months of age, a decline in maternal antibody titres predisposes the age group of 3-6 months to CPV infection and increases susceptibility to infection in endemic areas due to lack of protective titres (O'Brien, 1994; Deka *et al.,* 2013) [21, 7].

Sex wise prevalence of CPV infection was found to be more in males (63.57%) compared to females (34.43%) which are supported by the findings of Sagare *et al.,* (2022) [25]; Singh *et al.,* (2021) [34] and Sayed-Ahmed *et al.,* (2021) [27] respectively (Table 2) (Figure 4). In contrast, Banja *et al.,* (2002) [3] and Sanjukta *et al.,* (2011) [26] in respective studies reported that no significant difference was observed among sexes of dogs with CPV infection as there was no influence of sex on the incidence of CPV infection. Higher incidence in males might be due to selective pattern of keeping male dogs by owners and more chance of exposure due to certain behavioural patterns. Also, more male dogs being presented to the clinics will contribute to its higher incidence. Also, mostly male dogs were kept for breeding purposes by a greater percentage of population (Deka *et al*., 2013; Thomas *et al.,* 2014) [7, 36].

Season wise incidence of CPV was found to be highest in spring 86/258 (33.33%) and winter 75/258 (29.07%) respectively, followed by Autumn 53/258 (20.54%) and least in Summer 53/258 (17.05%) which is supported by findings of Mehta *et al.,* (2017) [18] who noted higher prevalence during the winter season (58.67%) followed by summer (37.50%) and the least in monsoon (18.42%) season (Table 2) (Figure 5). This might be due to the ensuing of more whelping during the time period of November and December. Moreover, it might be due to cold climate where virus can survive and multiply rapidly as compared to other months. Qi *et al*., (2020) [23] stated that higher prevalence during winter and early spring might me due to significant seasonal diurnal temperature differences and changeable climates during these seasons. In contrast, Sayed-Ahmed *et al.,* (2021) [27] reported that regarding season, higher prevalence was noticed in summer (77.1%) followed by spring (55.5%), autumn (25%) and winter (16.6%). Kalli *et al*., (2010) [12] stated that seasonal prevalence of the disease is subject to considerable variations in wide geographical areas and depending on seasonal variation, the occurrence of CPV-2 is believed to be a year-round phenomenon.

The overall prevalence of canine parvovirus infection in vaccinated and non-vaccinated animals was found to be 95/258 (36.82%) and 163/258 (63.13%) respectively which correlated with findings of Srinivas *et al.,* (2013) [31] and Singh *et al.,* (2021) [34], who reported higher percentages of 84.05% and 75.90% respectively in non-vaccinated animals (Table 2) (Figure 6). The higher prevalence of CPV infection in non-vaccinated dogs might be due to a lack of protective immunity as maternal antibodies gradually declines after a period of around 38 days. In vaccinated dogs, CPV infection might occur due to incomplete or ineffective primary vaccination course, or a failure of vaccination (Godsall *et al.,* 2010) [10]. Moreover, higher prevalence in non-vaccinated dogs indicates that current vaccines confer reasonably good protection (Nandi *et al.,* 2010) [20]. The time period called as the window of susceptibility usually lasting 2–3 weeks is during which the maternal antibody titre falls below the required protection level, but is high enough to prevent a vaccine to work and is able to neutralise the vaccine virus; thus, vaccination during this time period might result in failure thus pre-disposing the animal to infection. Also, in some cases, owners don't adhere to the vaccination schedules advised by their veterinarians and increased delays between the first and second doses reduce these secondary antibody responses, thus both the length and quality of the immunity produced. Moreover, an adequate level of immunity usually does not occur until 2-3 weeks after the second vaccination in the series and the dog is susceptible to the disease if it is exposed beforehand (Rashid *et al.,* 2009) [24].

Out of 258 cases confirmed, 65 cases (25.19%) were such that they underwent transportation/ relocation few days before development of signs and symptoms indicating transportation is a key predisposing factor contributing to the development of CPV infection; relocation of weaned pups is a stressful event; a mixture of different stressors such as unfamiliar environment, dietary changes, noise; all of these events would elicit stress response, including endocrine changes in dogs and elevated cortisol levels which induces immunosuppression (Tuber *et al.,* 1996; Spreng 2000) [8, 30] (Table 2) (Figure 7). Schoeman *et al.,* (2013) [28] observed that high serum cortisol and low thyroxine concentrations at 24 and 48 h post-admission were strongly associated with increased mortality in puppies with natural CPV enteritis. However, DiGangi *et al.,* (2021) [8] in a study in United States reported that the incidence of post-transport CPV diagnoses in the study population of 4088 puppies was only 2.3%.

Table 1: Overall prevalence of CPV infection in and around Pantnagar (June, 2021-June, 2022)

Overall affections of canines reported	Total cases of Gastroenteritis (GE)	CPV positive cases	Prevalence (%)
2068	258	627	41.15%

Table 2: Prevalence (%) of Canine Parvovirus on basis of breed, sex, age, season, vaccination status and relocation stress presented to VCC, Pantnagar

Variables	Number of dogs positive for CPV (n=258)	Prevalence (%)
Breed		
Mongrel	132	51.16
Pitbull	15	5.81
Rottweiler	21	8.14
German Shepherd	22	8.53
Miniature Pinscher	2	0.78
Pomeranian	5	1.94
Labrador retriever	25	9.69
Golden Retriever	12	4.65
Siberian husky	9	3.49
Himalayan sheep dog	6	2.33
German Spitz	4	1.55
Dalmatian	5	1.94
Cane Corso	5	2.09
Pug	6	2.51
Age		
<3months	81	31.40
3-6 months	112	43.41
6month-12 months	54	20.93
>12 months	11	4.26
Sex		
Female	94	34.43
Male	164	63.57
Season		
Spring	86	33.33
Summer	44	17.05
Autumn	53	20.54
Winter	75	29.07
Vaccination status		
Vaccinated	95	36.82
Non- vaccinated	163	63.13
Relocation stress		
Underwent relocation	65	25.19
No relocation	193	74.80

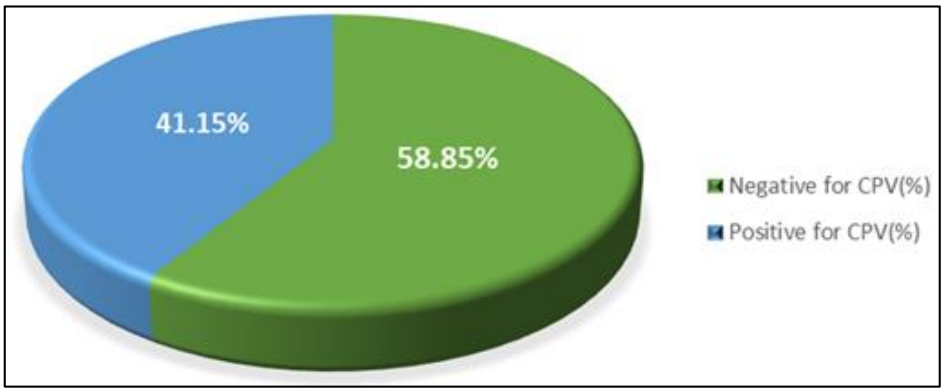

Fig 1: Overall CPV positive cases among reported cases of Gastroenteritis

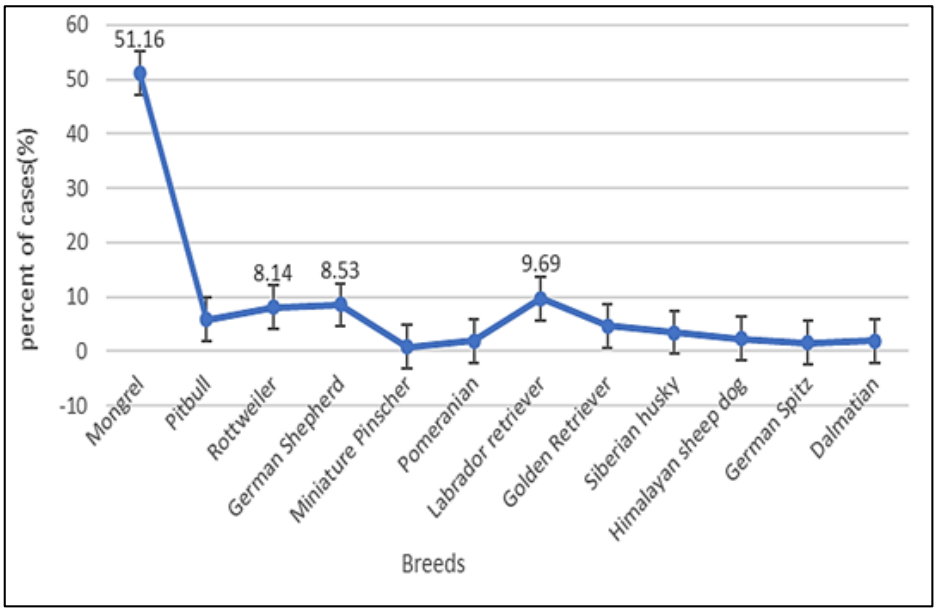

Fig 2: Line graph showing prevalence of CPV infection in relation to breed

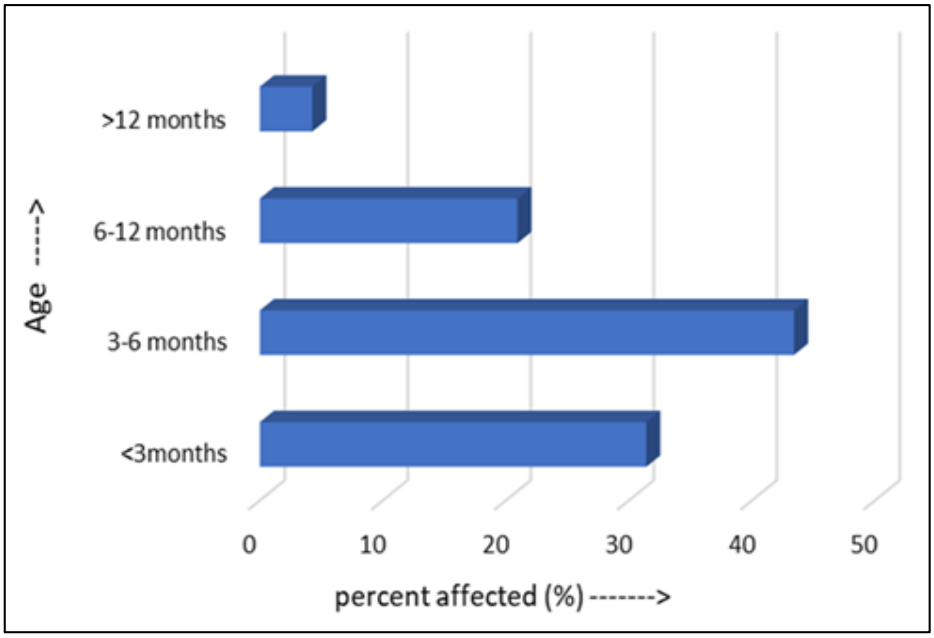

Fig 3: Bar diagram showing prevalence of CPV infection in relation to age

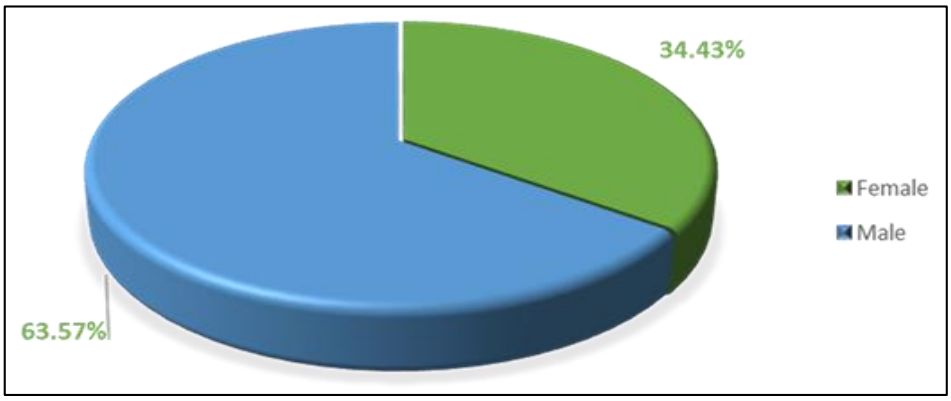

Fig 4: Pie chart showing prevalence of CPV infection in relation to sex

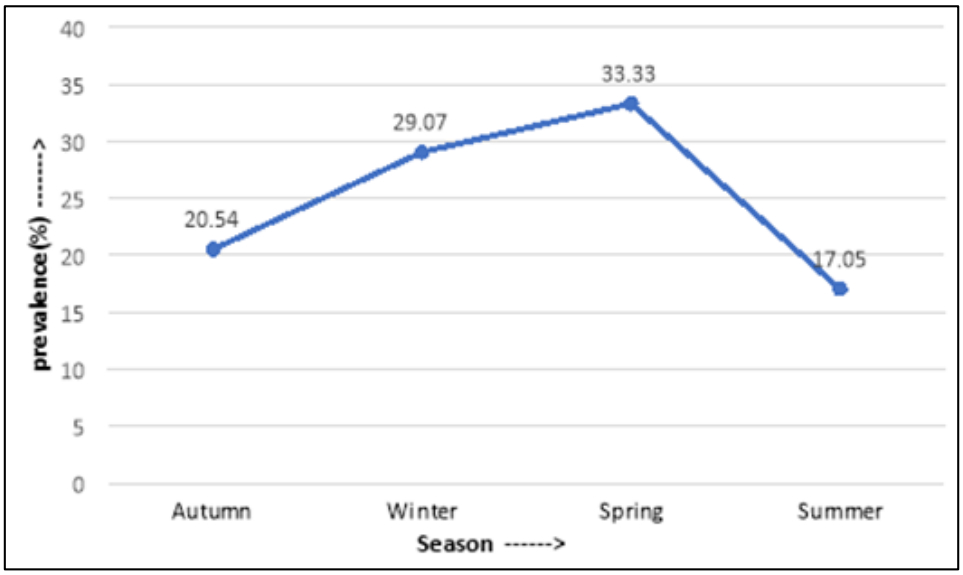

Fig 5: Line graph showing prevalence of CPV infection season-wise

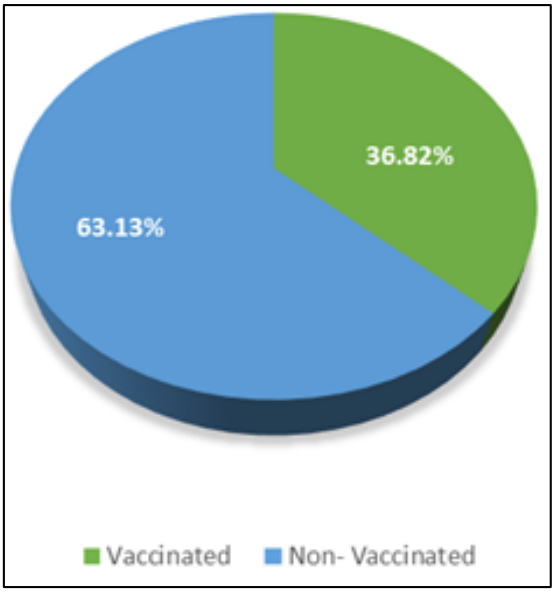

Fig 6: Pie chart showing CPV prevalence as per vaccination status

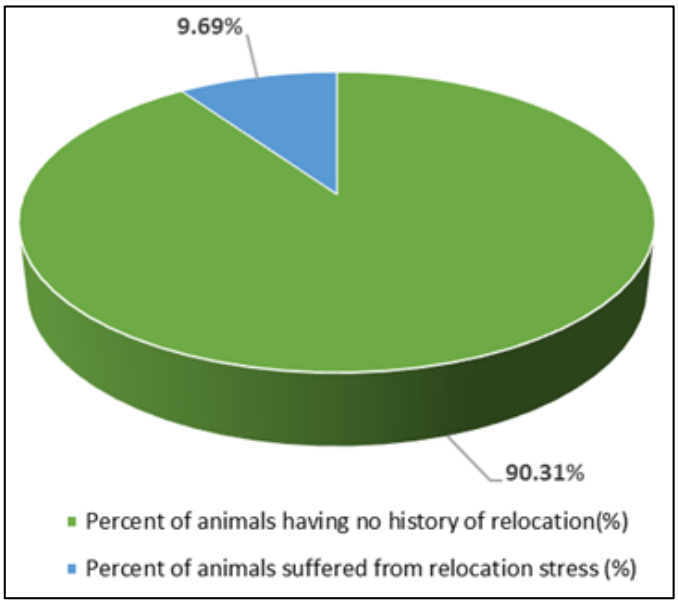

Fig 7: Pie chart showing CPV prevalence as per relocation status

Conclusion

The prevalence of CPV infection at VCC, Pantnagar during the period from June, 2021 to June, 2022 was 41.15%. Highest prevalence was observed in non-descript dogs, and among the exotic breeds, Labrador retriever was found to be highly prevalent comparatively. CPV infection was higher in age groups of less than 3 months of age (31.40%) and in 3- 6 months (43.41%), whereas sex wise prevalence was higher in males (63.57%) respectively. Season wise, higher rates were evident in spring (33.33%) and winter (29.07%) respectively. About 63.13% of the positive cases were non- vaccinated and 25.19% of cases were such that they underwent relocation few days prior to developing the disease. Canine Parvovirus infection in case of young pups is a deadly disease if unvaccinated or deprived of maternal antibodies; the severe form of the disease requires aggressive form of management in a very young age which, consequently affects the overall growth and health of the animal in the upcoming years of life.

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