Veterinary Research Communications, 13 (1989) 205–212

VIRAL HAEMORRHAGIC DISEASE IN RABBITS: A REVIEW

Z.J. XU AND W.X. CHEN[1]
Department of Veterinary Medicine, Zhejiang Agricultural University, Hangzhou, People's Republic of China
[1]Current address: Department of Veterinary Pathology and Public Health, Massey University, Palmerston North, New Zealand

ABSTRACT

Xu, Z.J. and Chen, W.X., 1989. Viral haemorrhagic disease in rabbits: a review. *Veterinary Research Communications*, **13** (3), 205–212

An acute haemorrhagic disease of rabbits was first reported in a southern province of China in 1984. It subsequently spread rapidly to South China and some parts of North China. The disease is characterized by an acute onset with fever, rapid respiration and sudden death. There is a high morbidity and mortality rate. The pathological changes are consistent with severe generalized circulatory dysfunction (hyperaemia, congestion and haemorrhage), marked degeneration of parenchymatous tissue, pronounced serous-haemorrhagic pneumonia and extensive disruption of reticulo-lymphoid tissue. The disease has been named rabbit viral haemorrhagic disease and it has been suggested that the aetiological agent is a picornavirus. A tissue-derived vaccine has been prepared by homogenizing the liver, lung, spleen and kidney of infected rabbits and inactivating with formaldehyde. This review summarizes the information on the aetiology, epidemiology and clinical and pathological aspects of this new rabbit disease.

Keywords: rabbits, virus, pathology, epidemiology, diagnosis, control

INTRODUCTION

In early 1984 an acute fatal disease of rabbits, which could not be linked with any recognized syndrome described in the literature, was reported from many regions of China (Liu *et al.*, 1984; Pu *et al.*, 1984; Sheng *et al.*, 1985; Xu, H.X. *et al.*, 1985; Xu, Z.J. *et al.*, 1985; Cao *et al.*, 1986; Chen and Zeng, 1986; Gu *et al.*, 1986). The disease was variously described as rabbit plague (Chen and Zeng, 1986), rabbit viral septicaemia (Sheng *et al.*, 1985), rabbit viral haemorrhagic pneumonia (Pu *et al.*, 1985) and rabbit viral haemorrhagic disease (RVHD) (Liu *et al.*, 1984; Xu, F.N. *et al.*, 1985a; Xu, Z.J. and Chen, 1988). Since the clinical signs and pathological changes described from all regions have been remarkably similar and a common viral aetiology has been demonstrated, it is likely that all the reports refer to the same disease. The most widely accepted name is now rabbit viral haemorrhagic disease.

AETIOLOGY

A virus has been consistently isolated from the blood and various tissues of affected rabbits (Cao *et al.*, 1986; Chen, 1986; Gao *et al.*, 1986; Xu, Z.J. and Chen, 1988). The virus is non-enveloped, spherical in shape and has an average diameter of 30 nm

(range 28–42 nm) (Liu *et al.*, 1984; Pu *et al.*, 1984; Zhang and Zhang, 1985; Wei *et al.*, 1987). About 65 per cent of its particles have an electron-dense core measuring 23–27 nm in diameter (Liu *et al.*, 1984; Pu *et al.*, 1984) while the remainder are intact (Pu *et al.*, 1985). The nucleic acid is a single-stranded RNA (Liu *et al.*, 1984). The capsid is thought to be icosahedral and made up of 32 cylindrical capsomeres (Liu *et al.*, 1984; Pu *et al.*, 1984; Chen, 1986; Gao *et al.*, 1986). Estimates of the buoyant density of the virus particle by density gradient ultracentrifugation in caesium chloride solution have ranged from 1.30 to 1.34 g/cm^3 with a sedimentation coefficient of 162 S (Pu *et al.*, 1984; Chen, 1986). The molecular weight of the intact virion was reported as 26×10^6 u (Pu *et al.*, 1984). It has recently been suggested that the virus is a new member of the Picornaviridae (Pu *et al.*, 1985; Cao *et al.*, 1986). However, RVHD virus differs from other members of this family in some aspects of its morphological and physical features. It is generally larger, with a lower buoyant density, and it contains fewer capsomeres. The molecular weight is higher than that of other picornaviruses (approximately 8×10^6 u). Like the typical picornavirus, RVHD virus replicates in the cytoplasm of host cells. Large numbers of viral particles are present in the cytoplasm of host cells from both naturally and experimentally infected rabbits (Pu *et al.*, 1984). The concentration of the virus is highest in the liver, followed by the lung, kidney and spleen (Pu *et al.*, 1984; Chen, 1986).

The virus agglutinates erythrocytes of sheep, chicken and all types of human blood with human type O agglutinating most strongly (Liu *et al.*, 1984; Wang *et al.*, 1986b). The haemagglutination inhibition (HI) test has been used for the detection of anti-RVHD virus antibody in serum (Pu *et al.*, 1985). The virus does not agglutinate erythrocytes from horses, mules, donkeys, cattle, ducks, quails, dogs, pigs, geese, rabbits, guinea pigs, mice, nude mice, rats and some other rodents (Liu *et al.*, 1984; Xu, Y.M. *et al.*, 1985; Xu, Z.J. *et al.*, 1985; Chen, 1986; Tian, 1986; Wang *et al.*, 1986a; 1986b). The agglutination titre was significantly reduced after tissues were repeatedly frozen and thawed (Liu *et al*, 1984) or treated with 0.25% pancreatin (Wang *et al.*, 1986b) but no significant alteration or inhibition followed treatment with chloroform, exposure to pH from 3 to 8, heating to 50°C for 60 min or to 56°C for 15 min (Pu *et al.*, 1984; Wang *et al.*, 1986b).

No satisfactory methods have yet been found for culturing the virus. Although replication of RVHD virus in primary kidney cell cultures from suckling rabbits has been reported by some workers (Pu *et al.*, 1984), Chen (1986) failed to demonstrate viral replication in RK-13 cells or in a range of different primary cell cultures including kidney cells from suckling rabbits. However, the virus could be easily passaged in susceptible rabbits (Xu Z.J. *et al.*, 1985).

The viral infectivity was not reduced by treatment with ether, exposure to pH 3.0 or heating to 50°C. The virus was inactivated by 1% sodium hydroxide (Chen, 1986) or by 0.4% formaldehyde at ambient temperature, 4°C or 37°C. While formaldehyde eliminated the infectivity of the RVHD virus, it did not reduce its immunogenicity (Xu Z.J. *et al.*, 1985).

EPIDEMIOLOGY

Epidemics of RVHD can cause disastrous economic loss in the rabbit industry. Rabbits appear to be the only species susceptible to natural infection (Xu Z.J. *et al.*,

1985). Inoculations of tissue suspensions from infected rabbits failed to produce disease in guinea pigs, hamsters, rats, mice or chick embryos (Wang *et al.*, 1986a). There is no significant difference in the susceptibility to natural infection in different breeds of rabbits, although disease has been reported more frequently in fibre-producing breeds than in meat breeds (Xu Z.J. *et al.*, 1985). Outbreaks of RVHD have occurred mainly in rabbits aged two months or older (Xu Z.J. *et al.*, 1985; Cao *et al.*; 1986, Chen, 1986), while suckling rabbits are usually resistant to infection (Sun *et al.*, 1985; Xu H.X. *et al.*, 1985; Xu Z.J. *et al.*, 1985; Cao *et al.*, 1986).

Diseased and subclinically infected rabbits are the major sources of infection (Xu Z.J. *et al.*, 1985). It has been reported that the disease is mainly transmitted through direct contact between sick and healthy rabbits (Xu H.X. *et al.*, 1985; Xu Z.J. *et al.*, 1985). In addition, secretions and excretions of infected animals, contaminated feedstuffs, water, shears, utensils, vehicles and animal attendants have been shown to be important in transmitting the disease (Xu H.X. *et al.*, 1985; Xu Z.J. *et al.*, 1985). It has been suggested that the disease may be spread by airborne particles (Chen, 1986). The wool from diseased rabbits has been shown to carry the virus (Xu Z.J. *et al.*, 1985). Experimental studies showed that the main route of infection was oral, followed by conjunctival, nasal and skin trauma (Xie *et al.*, 1986). Although the morbidity induced by the different routes is similar under experimental conditions, mortality was higher in orally infected rabbits than in those infected by other routes (Xie *et al.*, 1986).

Epidemics of RVHD usually start in November and wane during March of the following year (Xu Z.J. *et al.*, 1985). The decreased incidence of the disease in summer and autumn is thought to be associated with higher environmental temperatures which may influence the survival of the virus (Liu *et al.*, 1984; Xu H.X. *et al.*, 1985; Xu Z.J. *et al.*, 1985).

CLINICAL SIGNS

RVHD is an acute and highly infectious disease which attacks rabbits raised in intensive conditions (Cao *et al.*, 1986). Following experimental infection, the incubation period is about 20–48 h, with a mortality rate of approximately 90% (Pu *et al.*, 1984). In natural cases, the incubation period ranges from several hours to one or two days (Liu *et al.*, 1984; Xu Z.J. *et al.*, 1985). The morbidity rate in natural outbreaks is 70–80% with up to 100% mortality in affected rabbits (Xu Z.J. *et al.*, 1985; Chen, 1986). Epidemics usually peak 2–3 days after the disease has been introduced and last for 7–13 days (Xu Z.J. *et al.*, 1985). Outbreaks in different regions showed many similarities and may be divided into three categories:

1. *The peracute form.* Peracute RVHD is usually seen when the disease is first introduced (Xu Z.J. *et al.*, 1985). Infected rabbits often die suddenly without any clinical abnormality being seen (Liu *et al.*, 1984; Xu H.X. *et al.*, 1985). Occasionally, a haemorrhagic foamy discharge from the nostrils and vaginal haemorrhage are observed (Xu Z.J. *et al.*, 1985).

2. *The acute form.* Acute RVHD predominates in areas where the disease has become epidemic (Xu Z.J. *et al.*, 1985). The infected animals usually show depression,

reluctance to move and anorexia. The body temperature is often elevated to 41°C or higher in the early and developing stages of the disease and then drops below normal in the terminal stages (Xu Z.J. and Chen, 1988). Most animals have rapid respiration and cyanosis of the visible mucosae and skin. Some animals show abdominal distension, constipation or diarrhoea and haematuria (Chen, 1986). Eventually, the animals become recumbent and make paddling movements of the limbs. Some animals die during convulsions. Others become frenetic in their cages and cry out before death (Chen, 1986). About 20% of the affected rabbits have a foamy haemorrhagic discharge from the nostrils (Xu Z.J. *et al.*, 1985). The course of acute RVHD is between 12 and 36 h (Chen, 1986).

3. *The subacute form.* Subacute RVHD is frequently encountered in the later stages of an epidemic (Xu Z.J. *et al.*, 1985; Xu Z.J. and Chen, 1988). The rabbits exhibit depression, anorexia and high body temperatures similar to those seen in the acute form. These clinical signs usually last for two to three days and the majority of infected animals survive. Such animals are resistant to re-infection (Xu Z.J. and Chen, 1988).

Haematological examinations usually reveal a severe decrease in the total leukocyte numbers (Chen, 1986). The leukopenia is due to a decrease in the proportion of lymphocytes, which falls from about 73% in healthy rabbits to about 34% in diseased animals. However, elevated total leukocyte counts have occasionally been reported (Chen *et al.*, 1987).

PATHOLOGICAL CHANGES

The pathological changes in both naturally occurring and experimentally induced cases of RVHD have been extensively studied by many workers (Liu *et al.*, 1984; Sheng *et al.*, 1985; Xu F.N. *et al.*, 1985a; Xu Z.J. *et al.*, 1985; Xu Z.J. and Chen, 1988). Disease is readily produced by inoculation of susceptible rabbits, with suspensions prepared from the liver and lung of diseased animals, by various routes including subcutaneous, intramuscular, intraperitoneal, intrathoracic, oral, nasal or by skin prick (Pu *et al.*, 1984; Xu Z.J. *et al.*, 1985; Cao *et al.*, 1986; Chen, 1986). Experimentally infected animals show clinical and pathological changes very similar to those seen in natural cases (Pu *et al.*, 1984; Xu Z.J. *et al.*, 1985).

The pathological changes are believed to result from a viraemia with widespread circulatory dysfunction (Xu F.N. *et al.*, 1985a; Xu Z.J. *et al.*, 1985). Although petechial haemorrhage, generalized congestion and poor blood coagulation occur in almost all organs, the trachea and lungs are grossly most severely affected (Sheng *et al.*, 1985; Xu F.N. *et al.*, 1985a; Xu Z.J. *et al.*, 1985; Chen and Zeng, 1986; Xu Y.M. *et al.*, 1986; Xu Z.J. and Chen, 1988).

Histopathological changes have been described in the respiratory tract, liver, kidneys and lymphoid tissues. Changes described in the lung were fairly consistent and could be generally divided into three types: 1) hyperaemia and haemorrhage, 2) congestion, haemorrhage and oedema and 3) serous-haemorrhagic pneumonia (Chen and Zeng, 1986). The inflammatory cells infiltrating the airways and alveoli were predominantly macrophages and neutrophils (Xu Z.J. *et al.*, 1985; Chen and Zeng, 1986; Xu Z.J. and Chen, 1988). The latter changes may result from secondary

bacterial infection, although they are also present in experimentally infected animals. Focal aggregations of lymphocytes and eosinophils in the peribronchiolar and perivascular areas have also been observed in some animals (Chen and Zeng, 1986).

Lesions in the liver usually included marked congestion and moderate fatty degeneration (Xu Z.J. *et al.*, 1985). Disseminated hepatic necrosis has also been described in many cases (Sheng *et al.*, 1985; Xu Z.J. *et al.*, 1985). The gall bladder is usually distended with bile and petechial haemorrhages and focal coagulative necrosis may be observed in the mucosae (Xu F.N. *et al.*, 1985a; Chen and Zeng, 1986).

Extensive congestion and focal haemorrhage have been consistently described as the major renal changes in RVHD (Sheng *et al.*, 1985; Xu F.N. *et al.*, 1985a; Xu H.X. *et al.*, 1985; Chen and Zeng, 1986). Nephritis and membranous glomerulonephritis have been reported infrequently (Xu F.N. *et al.*, 1985a; Chen and Zeng, 1986). Large numbers of fibrinous thrombi were frequently found in the glomerular capillaries and some capillaries showed hyaline degeneration in the walls (Xu H.X. *et al.*, 1985).

In addition to haemorrhage and congestion of varying severity, the changes described in the lymphoid organs (lymph nodes, spleen, thymus, caecal tonsils and tonsils) consist mainly of depletion of lymphocytes, karyorrhexis and occasional karyolysis of the reticulo-lymphocytes (Sheng *et al.*, 1985; Xu Z.J. *et al.*, 1985; Chen and Zeng, 1986; Chen, 1986; Xu Z.J. and Chen, 1988). This depletion has been demonstrated to be closely correlated with the reduction in the total numbers of leukocytes in the peripheral blood (Chen *et al.*, 1987).

Some workers (Xu F.N. *et al.*, 1985a; Xu Z.J. *et al.*, 1985) have reported a non-suppurative encephalomyelitis characterised by perivascular aggregation of mononuclear cells, demyelination and glial proliferation, but this does not seem to be a consistent finding (Sheng *et al.*, 1985). Spherical and oval acidophilic inclusion body-like structures have occasionally been encountered in the cytoplasm of neurons and glial cells in the brain and spinal cord (Xu F.N. *et al.*, 1985a).

Changes reported in other tissues include catarrhal gastritis (Xu F.N. *et al.*, 1985a), focal or diffuse adrenal cortical necrosis (Chen and Zeng, 1986), severe endometrial congestion with haemorrhage into the uterine lumen (Xu Z.J. *et al.*, 1985) and degeneration of the pancreatic acinar epithelial and islet cells (Sheng *et al.*, 1985).

PATHOGENESIS

Despite the comprehensive studies on the aetiology, epidemiology and pathology of RVHD the pathogenesis of this disease remains uncertain. It has been suggested that a viraemia is responsible for the lesions (Xu F.N. *et al.*, 1985a), the sudden death of the animals being due to multiple organ dysfunction associated with extensive pulmonary congestion and oedema, severe serous-haemorrhagic pneumonia, focal haemorrhage and necrosis of the adrenal cortex, generalized circulatory disorders of kidneys and hepatic necrosis.

Disseminated intravascular coagulation (DIC) may be significant in the development of the disease (Sheng *et al.*, 1985; Xu Y.M. *et al.*, 1986; Chen, 1986). The main evidence to support this suggestion is the presence of numerous fibrinous thrombi in the capillaries of the kidney, lung, liver, brain and some organs in naturally occurring RVHD (Sheng *et al.*, 1985; Chen, 1986; She *et al.*, 1986; Xu Y.M. *et al.*,

1986). Studies on experimentally infected rabbits have demonstrated a gradual reduction in thrombocyte numbers to less than 50 000/mm^3 together with prolonged prothrombin and thrombin times. The paracoagulation test with protamine sulphate in these rabbits gave a strong positive reaction (Xu Y.M. *et al.*, 1986). Thus it is likely that DIC is an intermediate step in the development of acute RVHD, which may account for the sudden death of some of the infected animals.

Cytoplasmic vacuolization, swelling and degeneration of the mitochondria and rupture of the plasma membranes of cells of parenchymatous organs (lungs and liver) and their associated endothelial cells were common ultrastructural changes (She *et al.*, 1986; Wei *et al.*, 1987). Virions were observed densely arranged within the cytoplasm of these cells, indicating that the virus had a predilection for vascular and reticular endothelia (Zhang and Zhang, 1985; Chen, 1986; She *et al.*, 1986). The damage to the vascular endothelium is likely to initiate blood coagulation as well as secondary fibrinolysis, resulting in the development of DIC (Xu Y.M. *et al.*, 1986).

The presence of excess numbers of mast cells in the glomerular capillaries has been noted by Xu F.N. *et al.* (1985b) in their ultrastructural study. Mast cells are able to release many inflammatory mediators associated with type I allergic reactions. The histamine released from mast cells could also increase the permeability of the capillaries. In addition, it was suggested that the pathogenesis of RVHD might also be associated with the deposition of immunoglobulin and immune complexes, since there were lumps of dense, osmophilic material with fine granules deposited in many areas of the basal lamina (Xu F.N. *et al.*, 1985b). However, the infrequent occurrence of these changes and the extremely short course of the disease make it improbable that this is a fundamental mechanism in its pathogenesis.

DIAGNOSIS

A provisional diagnosis of RVHD can be made based on the epidemiological features, clinical signs and characteristic pathological changes. It is necessary, however, to differentiate RVHD from similar acute diseases, including rabbit pox, pasteurellosis and clostridial enterotoxaemia (Liu *et al.*, 1984; Sheng *et al.*, 1985; Xu Z.J. *et al.*, 1985). Confirmation of the diagnosis is dependent upon laboratory examination. The liver, lungs and kidneys from affected rabbits have been most useful for demonstrating viral particles by electromicroscopy (Xu Z.J. *et al.*, 1985). Viral particles, ranging in size from 28 to 34 nm, are frequently found in the cytoplasm of hepatocytes and type I pneumocytes (Xu F.N. *et al.*, 1985b). Disruption of tissues, by freezing and thawing or sonication, followed by centrifugation has proved useful for demonstrating viral particles (Chen, 1986).

Other laboratory diagnostic techniques include the haemagglutination (HA) test and serological tests. Because RVHD virus can agglutinate type O human erythrocytes, the HA test is very useful for preliminary identification of RVHD virus antigen in tissue suspensions from infected animals (Liu *et al.*, 1984; Xu Z.J. *et al.*, 1985; Pu *et al.*, 1985; Tian, 1986; Chen, 1986). Positive reactions could be detected even when the tissue suspensions were highly diluted (Pu *et al.*, 1985). The available data reveal that agglutination titres are highest with extracts from the liver, lung, spleen and kidney, moderate with extracts from the heart, brain and mesenteric lymph nodes and low with extracts from muscle. This is believed to reflect the viral

concentrations in the corresponding tissues (Lei *et al.*, 1985). The most reliable and practicable serological test for measuring serum antibody against RVHD virus is the haemagglutination inhibition (HI) test, which is now widely applied in the field (Pu *et al.*, 1985). The enzyme-linked immunosorbent assay (ELISA) (Hu *et al.*, 1986) and staphyloccocal protein A-ELISA (SPA-ELISA) (Xiang and Qu, 1986) have also been shown to be accurate and rapid diagnostic techniques.

CONTROL AND PREVENTION

No treatments are effective against RVHD, so control depends on general preventive measures including quarantine and vaccination.

Measures to prevent the introduction of RVHD into a rabbit farm or colony are similar to those used for any other infectious disease where direct contact is an important means of transmission. Restricted access and fumigation and disinfection of all equipment entering or leaving a site are desirable. It is essential that no rabbits are introduced from epidemic areas. If this cannot be avoided, it is recommended that all introduced rabbits are quarantined for at least two weeks and vaccinated at least one week before entry (Xu Z.J. *et al.*, 1985; Chen, 1986). Adequate disposal of diseased and dead rabbits in epidemic areas is essential. Disinfection with 1–2% sodium hydroxide or 10% formaldehyde solution is recommended for utensils, rabbit cages and other equipment (Xu Z.J. and Chen, 1988).

Vaccination of all susceptible rabbits is important in epidemic areas or areas at risk of introduction. A tissue-derived vaccine, inactivated with 0.4% formaldehyde, has been developed for prophylaxis against RVHD (Xu Z.J. *et al.*, 1985). Both laboratory and field trials have established its safety, potency and ease of application (Xu Z.J. *et al.*, 1985; Gu *et al.*, 1986). Rabbits are protected by four to five days after vaccination and immunity can last as long as five months (Xu Z.J. *et al.*, 1985; Xu Z.J. and Chen, 1988).

ACKNOWLEDGEMENT

The authors would like to thank Dr C.R. Wilks for his critical reading of this paper.

REFERENCES

Cao, S.Z., Liu, S.G., Gan, M.H., Liu, R.P., Cai, S.W. and Liu, S.F., 1986. A preliminary report on viral haemorrhagic pneumonia (tentative name) in rabbits. *Chinese Journal of Veterinary Medicine* (in Chinese), **12**, 9–11

Chen, K.Y., 1986. Rabbit plague. *Infectious Diseases in Domestic Animals* (in Chinese), **3**, 53–55

Chen, K.Y. and Zeng, D.N., 1986. Report on 100 cases of rabbit plague. *Infectious Diseases in Domestic Animals* (in Chinese), **3**, 46–48

Chen, K.Y., Zeng, D.N., Ning, L.Z. and Yin, L.Y., 1987. Changes in blood leucocytes and histology of lymphoid organs in acute phase of experimentally infected rabbit viral haemorrhagic disease. *Chinese Journal of Veterinary Science and Technology*, (in Chinese), **5**, 38–40

Gao, J.L., Shao, T.H., Yu, H.L., Wang, Y.K. and Huo, H.F., 1986. Observation on morphology of a virus isolated from rabbit viral haemorrhagic disease. *Chinese Journal of Rabbit Farming* (in Chinese), **1**, 45

Gu, Z.D., Wang, X.X., Li, Q.Z. and Sun, F.F., 1986. An inactivated vaccine against haemorrhagic pneumonia in rabbits. *Chinese Journal of Veterinary Medicine*, (in Chinese), **12**, 50–51

Hu, B.Q., Wang, C.P., Cu, S.W. and Yue, W.X., 1986. Diagnosis of viral haemorrhagic disease in rabbits. *Chinese Journal of Veterinary Science and Technology*, (in Chinese), **6**, 35–37

Lei, Y.X., Yao, L.T. and He, S.L., 1985. Detection of haemagglutination titre in tissues from rabbits infected with rabbit viral haemorrhagic disease. *Shanghai Journal of Animal Husbandry and Veterinary Medicine*, (in Chinese), **6**, 19–20

Liu, S.J., Xue, H.P., Pu, B.Q. and Qian, N.H., 1984. A new viral disease in rabbits. *Animal Husbandry and Veterinary Medicine*, (in Chinese), **16**, 253–255

Pu, B.Q., Qian, N.H. and Cui, S.J., 1985. HA and HI tests for the detection of antibody titres to so-called 'haemorrhagic pneumonia' in rabbits. *Chinese Journal of Veterinary Medicine* (in Chinese), **11**, 16–17

Pu, B.Q., Xu, H.X. and Zhou, T., 1984. Outbreak of a viral infectious disease in rabbits in Wuxi Prefecture. *Shanghai Journal of Animal Husbandry and Veterinary Medicine*, (in Chinese), **6**, 15–16

She, R.P., Chen, D.W. and Gao, Q.Y., 1986. Observation on the ultrastructures of host cells in rabbit viral haemorrhagic disease. *Chinese Journal of Veterinary Medicine*, (in Chinese), **12**, 2–4

Sheng, Y.X., Wang, Z.J. and Xu, Y.F., 1985. Pathological studies on a viral septicaemia in rabbits. *Shanghai Journal of Animal Husbandry and Veterinary Medicine* (in Chinese), **4**, 3–6

Sun, H.C., Wang, Y.K., Zhou, Y.S. and Tian, H.F., 1985. Studies on susceptibility of rabbits to a virus isolated from rabbit viral haemorrhagic disease. *Chinese Journal of Rabbit Farming*, (in Chinese), **4**, 43–44

Tian, H.F., 1986. Detection of haemagglutination titre in tissues from rabbits infected with a viral disease. *Chinese Journal of Rabbit Farming*, (in Chinese), **1**, 44

Wang, Y.K., Sun, H.C. and Zhou, Y.S., 1986a. Studies on susceptibility of laboratory animals to a new rabbit virus. *Chinese Journal of Rabbit Farming* (in Chinese), **2**, 34

Wang, Y.K., Tian, H.F., Qian, Z., Chen, X.C. and Yu, Y.H., 1986b. Studies on haemagglutination of a virus isolated from rabbit viral haemorrhagic disease. *Chinese Journal of Rabbit Farming*, (in Chinese), **1**, 41–43

Wei, J.S., Yu, N.S., Yang, Y.F., Zhang, X.S., Long, P.R. and Shen, J.R., 1987. Investigation on a viral haemorrhagic disease in rabbits in Yunan Province. *Chinese Journal of Veterinary Science and Technology*, (in Chinese), **8**, 20–24

Xiang, X.C. and Qu, Y.M., 1986. Diagnosis of rabbit plague with SPA agglutination tests. *Chinese Journal of Veterinary Science and Technology*, (in Chinese), **3**, 34–35

Xie, M.L., Cheng, C.P., Wei, H.J., Chen, K.Y. and Yin, L.Y., 1986. Investigation on the infectious routes of rabbit plague. *Infectious Diseases in Domestic Animals*, (in Chinese), **6**, 4

Xu, F.N., Shen, W.P. and Liu, S.J., 1985a. Study of the pathology of viral haemorrhagic disease in rabbits. *Animal Husbandry and Veterinary Medicine* (in Chinese), **17**, 153–155

Xu, F.N., Shen, W.P. and Xi, Q.K., 1985b. Ultrastructural studies on viral haemorrhagic disease in rabbits. *Animal Husbandry and Veterinary Medicine* (in Chinese), **17**, 244–245

Xu, H.X., Pu, B.Q., Shi, D.M. and Fan, J.Z., 1985. Epidemiology of an infectious viral disease in rabbits in Wuxi County. *Shanghai Journal of Animal Husbandry and Veterinary Medicine*, (in Chinese), **3**, 14–16

Xu, Y.M., Wang, B.A. and Wang, Y.K., 1986. Studies on the induction of disseminated intravascular coagulation by a rabbit viral haemorrhagic disease virus. *Chinese Journal of Rabbit Farming*, (in Chinese), **4**, 36–38

Xu, Y.M., Wang, Y.K. and Wang, B.A., 1985. Histopathological observation on a rabbit viral disease. *Chinese Journal of Rabbit Farming* (in Chinese), **3**, 39–40

Xu, Z.J. and Chen, J.X., 1988. Studies on viral haemorrhagic syndrome in rabbits. *Acta Agriculturae Universitatis Zhejiangensis* (in Chinese, with English abstract), **14**, 136–141

Xu, Z.J., Chen, W.X., Chen, J.X. and Yu, J.Y., 1985. Studies on control and prevention of a new rabbit disease. *Zhejiang Journal of Animal Husbandry and Veterinary Medicine*, (in Chinese), **10**, 12–13

Zhang, Z.F. and Zhang, W.Q., 1985. Electronmicroscopic observations on the causing agent of a new viral disease in rabbits. *Shanghai Journal of Animal Husbandry and Veterinary Medicine* (in Chinese), **4**, 1–3

(Accepted: 6 January 1989)