生猪产业中不可忽视的腹泻病毒--轮状病毒的现状和未来

A key enteric virus of pig industry : future and now of Porcine Rotavirus

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01 Epidemic investigation of PoRV
轮状病毒及其流行

02 Pathogenicity of PoRV
轮状病毒的致病性及危害

03 Strategies against PoRV infection
猪轮状病毒的防控策略

轮状病毒的发现与流行 The discovery and prevalence of rotavirus

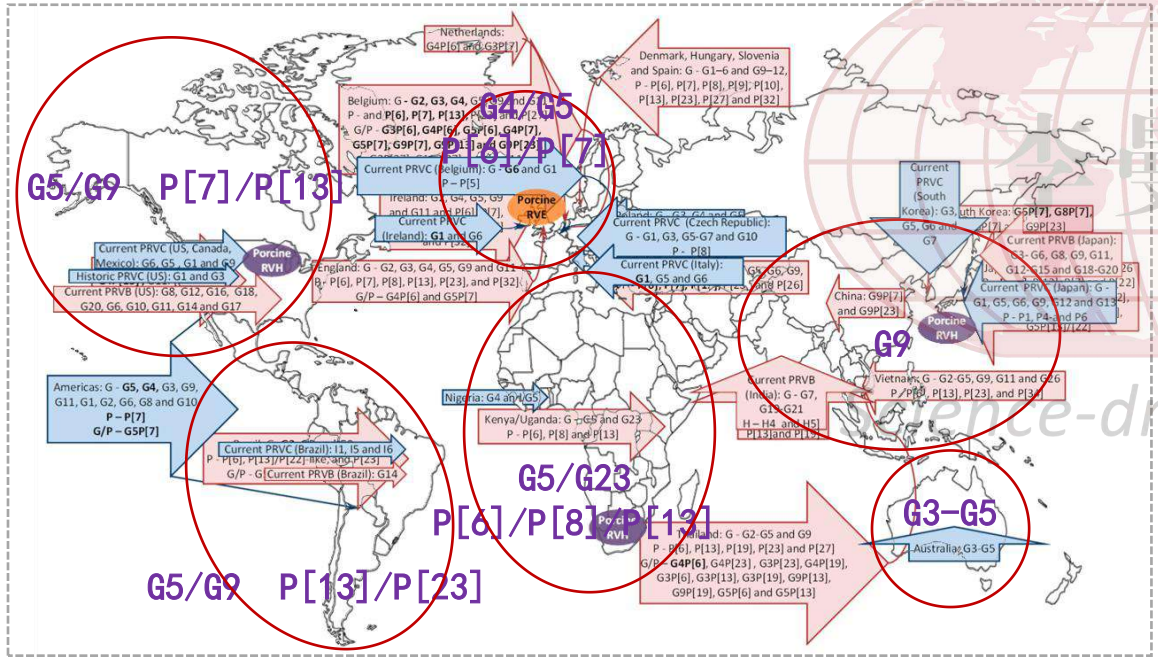
1969年
首次分离牛RV，并发现PoRV
First separation of bovine RV and discovery of PoRV

1973年
首次发现人RV
First discovery of human RV

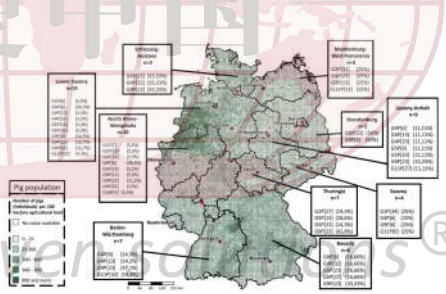
1980年
首次在仔猪分离PoRV
First isolation of PoRV in piglets

1980-2000年
世界各地陆续检出PoRV
PoRV has been detected around the world

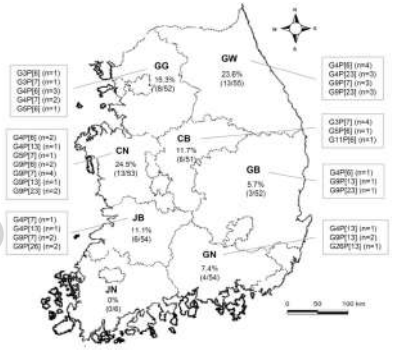
2000年-至今
PoRV A群呈全球大范围流行趋势
PoRV A group shows a global trend of widespread popularity



近年世界各地流行情况
In recent years, the epidemic situation around the world



G4/G9、P[6]/P[32]
(2018)



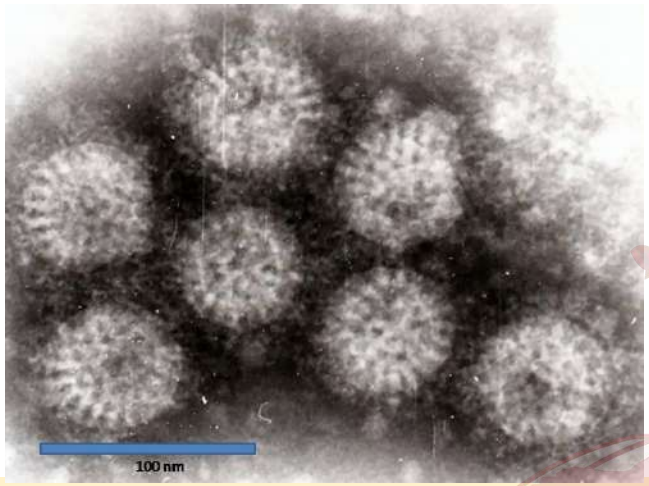
G4/G9、P[6]/P[7]
(2023)

G5/G9、P[13]/P[23]
(2021)

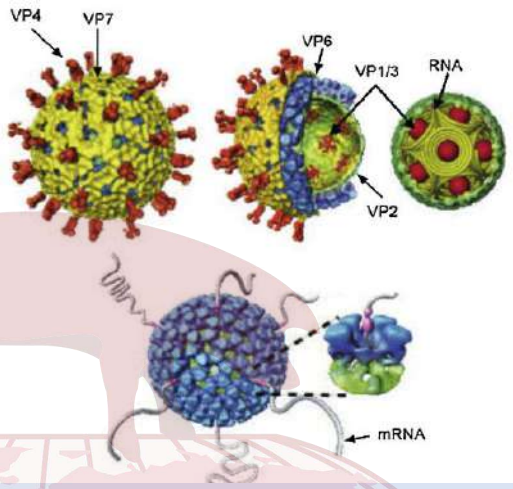
1976-2017年全球PoRV分布 Global PoRV distribution from 1976 to 2017

Vlasova, A.N et al., Viruses, 2017; Oliver Wenske et al., Veterinary Microbiology, 2018; Gyu-Nam Park et al., Viruses, 2023; Dragan Brnić et al., Viruses, 2022

轮状病毒 Rotavirus



轮状病毒最早于1973年在欧洲报道，因其病毒粒子外形而命名。
Rotavirus was first reported in Europe in 1973 and named after its viral particle morphology.



- 呼肠孤病毒科轮状病毒属
- Rotavirus genus of the family Enterovirus
- 二十面体对称结构
- Icosahedral symmetric structure
- 病毒基因组：11个dsRNA片段
- Virus genome: 11 dsRNA fragments
- 三层结构蛋白组成（TLPs）

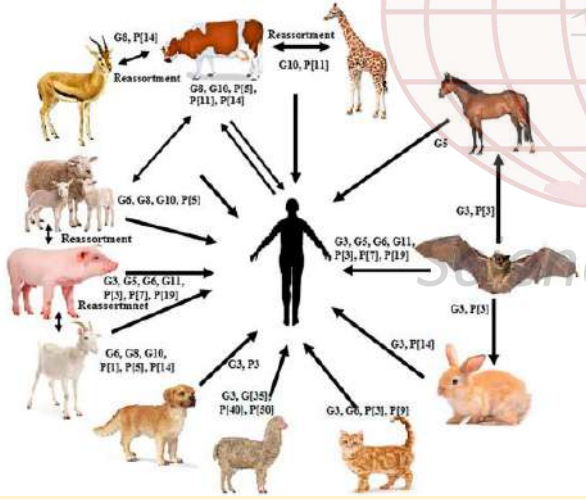
  Three layer structural protein composition (TLPs)

  最外层：VP4和VP7蛋白Outer layer: VP4 and VP7 proteins

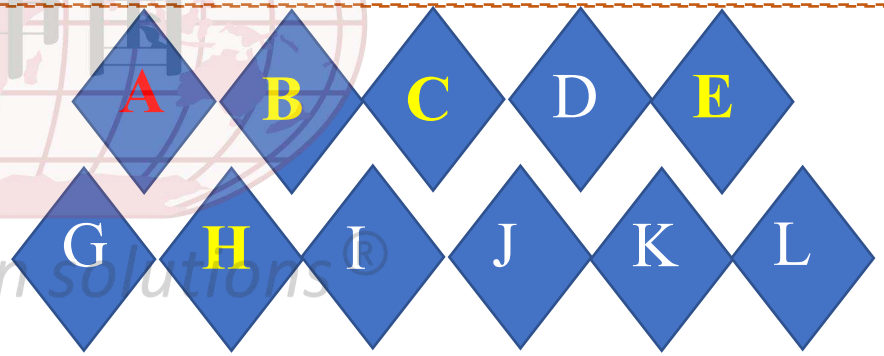
  中间层：VP6蛋白Intermediate layer: VP6 protein

  核心层：VP2、VP1和VP3蛋白Core layer: VP2, VP1, and VP3 proteins
- 非结构蛋白：NSP1-5 Non structural protein: NSP1-5

具有三层结构极大提高了病毒粒子稳定性
Having a three-layer structure greatly improves the stability of virus particles



宿主范围广
Wide host range



A群轮状病毒：42个G基因型，58个P基因型 (2024)
Group A rotavirus: 42 G genotypes, 58 P genotypes (2024)
C群轮状病毒： 9个G基因型， 7个P基因型
Group C rotavirus: 9 G genotypes, 7 P genotypes

具有多个血清型和基因型，以A型为主
Having multiple serotypes and genotypes, with type A being the main one

呼肠孤病毒科 Reoviridae

呼肠孤病毒分为12个属

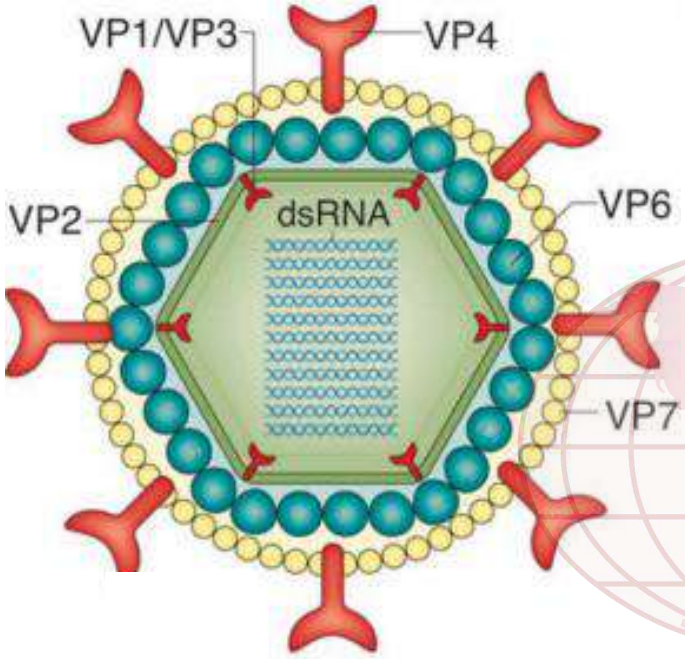
The reovirus is divided into 12 genera

- 感染脊椎动物的有6个属
- There are 6 genera that infect vertebrates
- 感染植物的有3个属
- There are three genera that infect plants
- 感染昆虫的有2个属
- There are two genera that infect insects
- 感染真菌的1个属
- One genus infected with fungi

猪轮状病毒属于呼肠孤病毒科轮状病毒属成员

Porcine rotavirus belongs to the family of enteroviruses and is a member of the genus Rotavirus

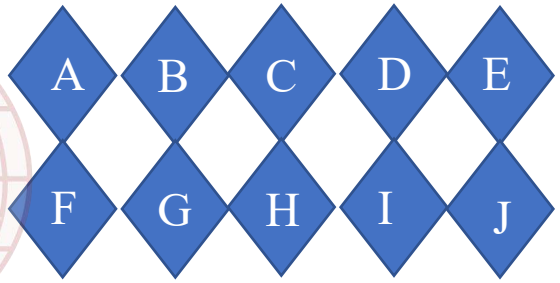
轮状病毒的分类
PoRV-classification



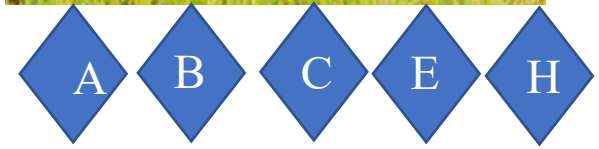
1973年发现并隔离。儿童和各种幼年动物的重要肠道病原体之一。

Discovered and isolated in 1973. One of the important enteric pathogens in children and in a wide range of young ainimals.

Based on VP6



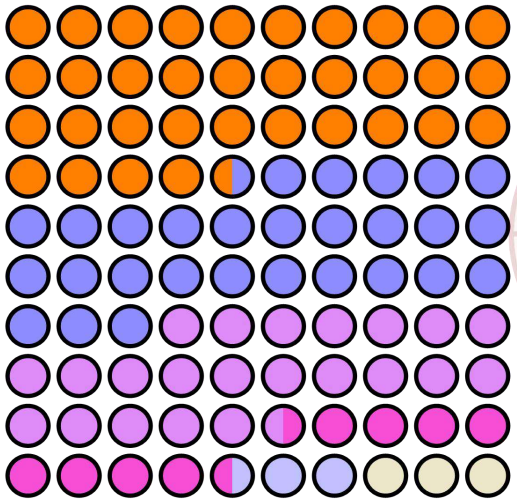
- **Reoviridae 呼肠孤病毒科**
- **Rotavirus 轮状病毒**
- **dsRNA virus 双链核糖核酸病毒**
- **VP1~VP4、VP6、VP7; NSP1~NSP5**



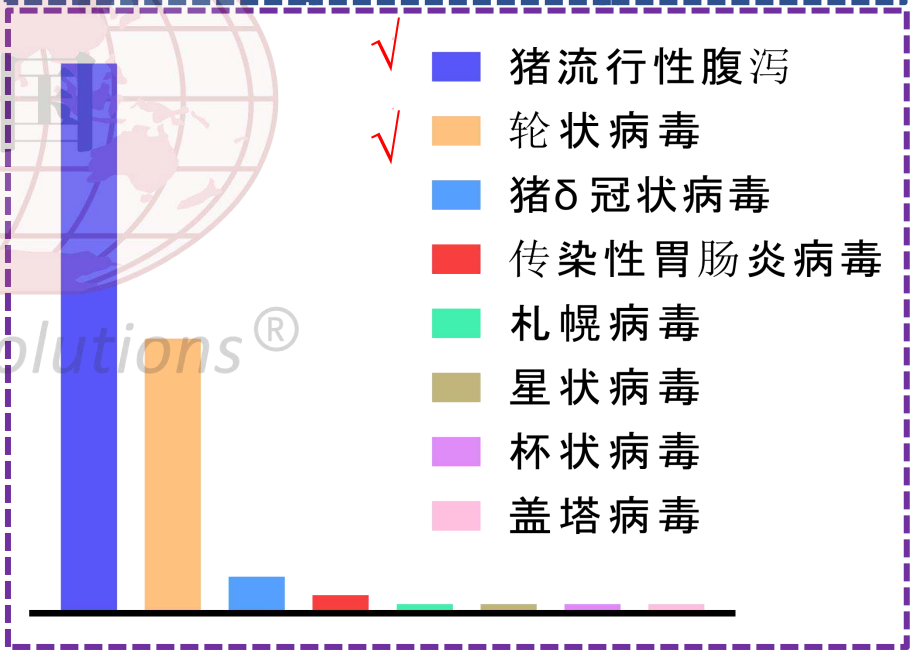
猪病毒性腹泻病原：种类多，但“重点”突出
Porcine viral diarrhea pathogen: There are many types, but the "key points" are prominent

根据23年9月-24年8月农业农村部疫情通报猪流行性腹泻仍然位居二类疫病报告病例“首位”

According to the epidemic notification of the Ministry of Agriculture and Rural Affairs from September 23 to August 24, porcine epidemic diarrhea still ranks first among the reported cases of Class II diseases



- 猪流行性腹泻
- 布鲁氏菌病
- 山羊传染性胸膜肺炎
- 猪繁殖与呼吸综合征
- 鸭瘟
- 小鹅瘟



轮状病毒与猪冠状病毒的感染后的主要区别

The main differences between rotavirus and porcine coronavirus after infection

日龄：轮状8周龄以内；冠状病毒 所有日龄均可发生临床症状

Age: within 8 weeks of age in a wheel shape; Clinical symptoms of coronavirus can occur at all ages

病原：轮状病毒，无囊膜； 冠状病毒，有囊膜

Pathogen: Rotavirus, non enveloped; Coronavirus, with a capsule

血清型：多抗原群，多血清型 冠状病毒：单一血清型，但有4种感染肠道的不同病毒

Serotype: multi antigen group, multi serotype coronavirus: single serotype, but there are 4 different viruses that infect the intestine

危害：轮状病毒更容易形成僵猪，死亡率低于冠状。

Harm: Rotavirus is more likely to form stiff pigs, with a lower mortality rate than coronaviruses.

流行情况：轮状病毒范围更广泛；冠状病毒流行面低于轮状

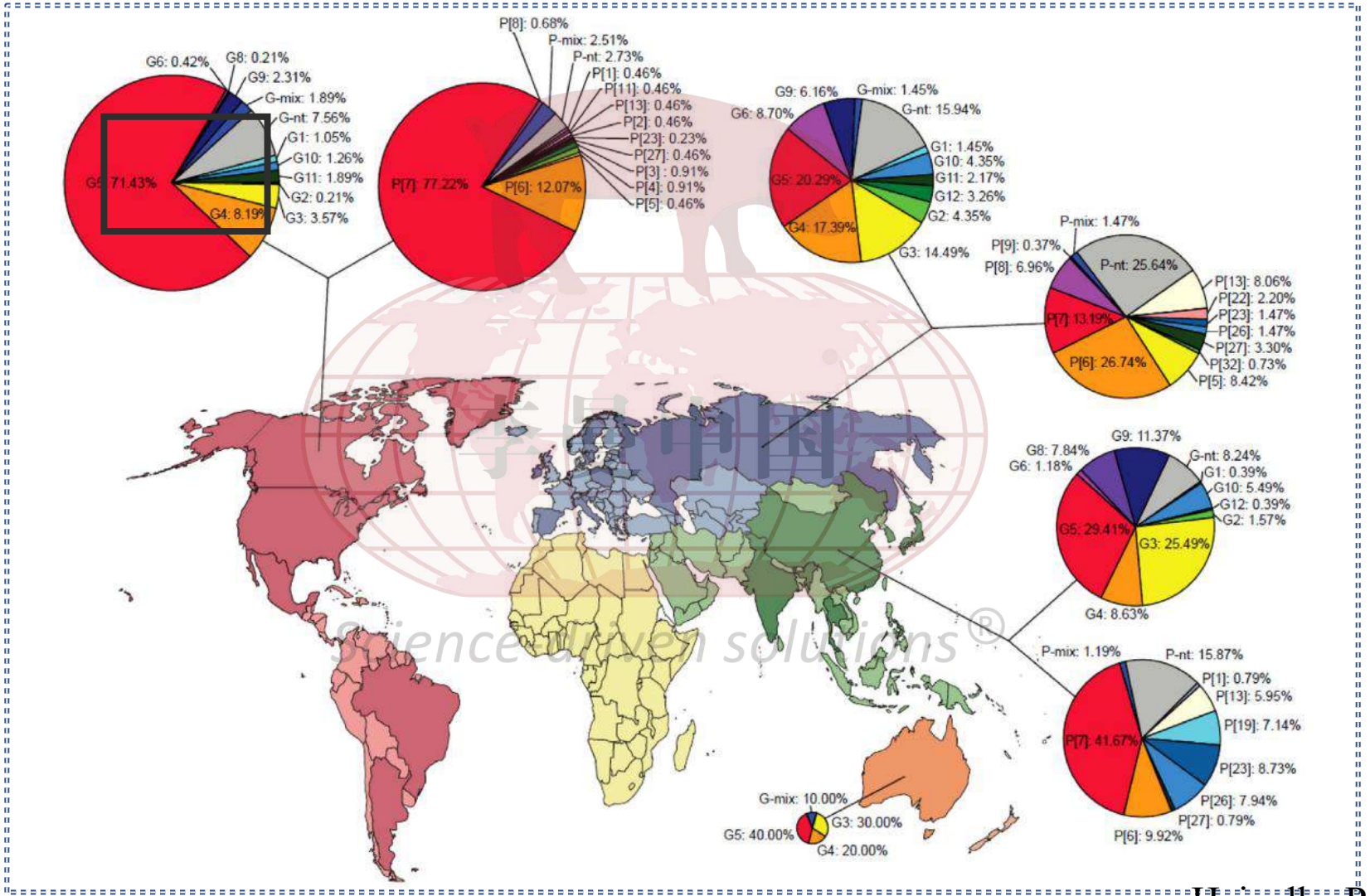
Epidemic situation: Rotavirus has a wider range; The prevalence of coronavirus is lower than that of rotavirus

宿主：轮状可感染多种动物；猪冠状大部分只感染猪

Host: Rotavirus can infect various animals; Most pig coronations only infect pigs

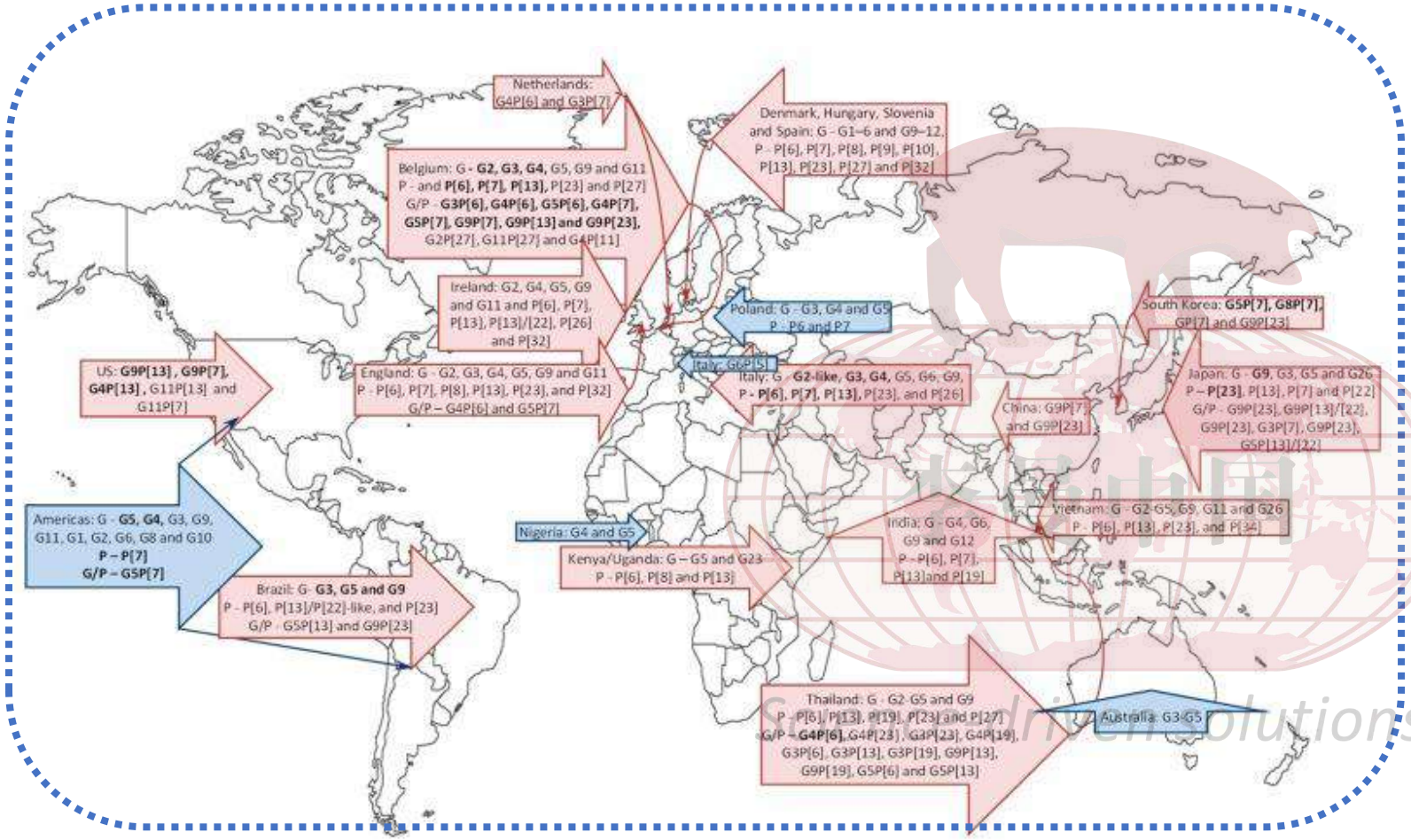
猪轮状病毒的主要基因型在世界的分布

Distribution differences of RVA strains in different regions



-----Hajnalka Pappet al.，2013

猪轮状病毒国外流行概况
Overview of Porcine Rotavirus Epidemic Abroad

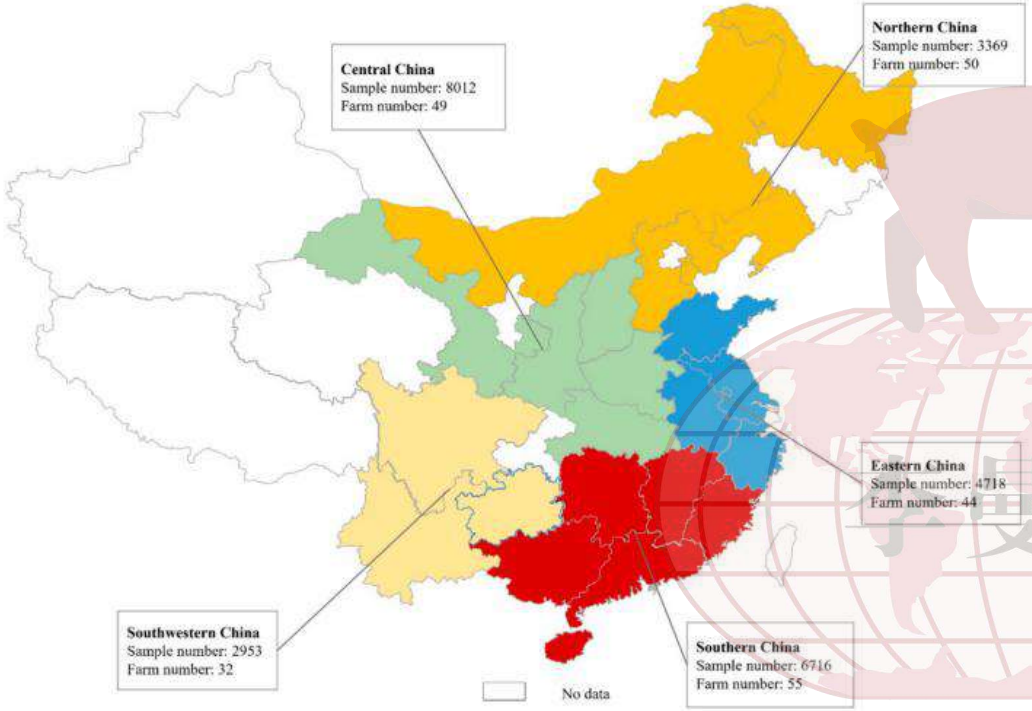


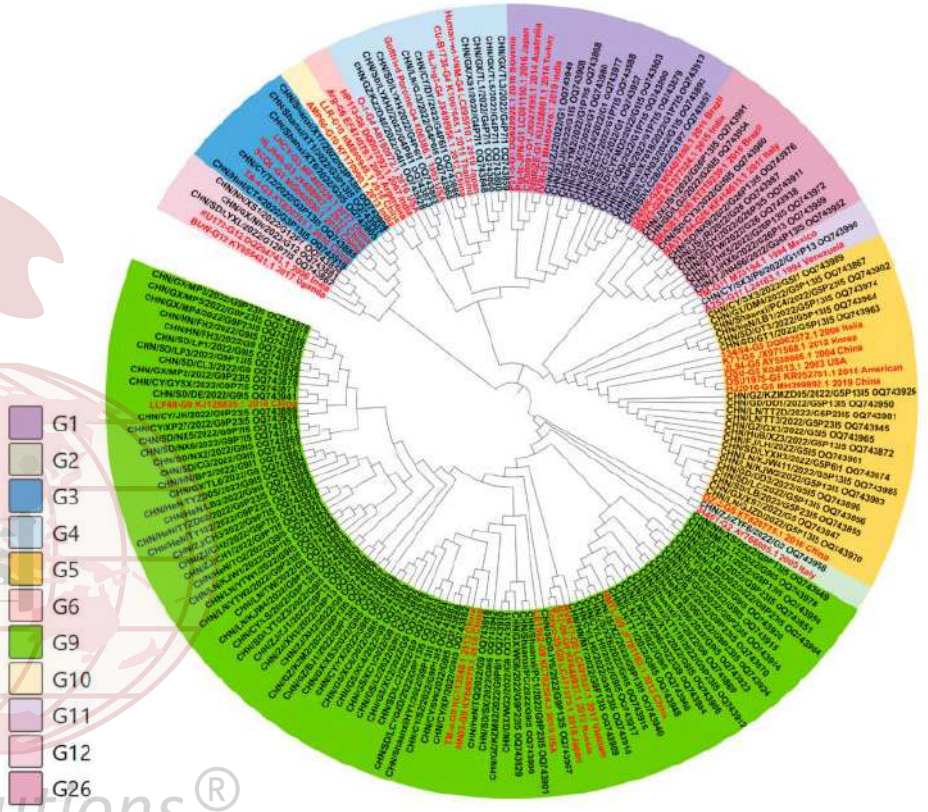
Anastasia N, Vlasova rt al. 2017

RVAs在全球流行情况示意图

- 目前在猪中共检测到12种G基因型 (G1-G6、G8-G12、G26) 和18种P基因型(P[1]-P[8]、P[11]、P[13]、P[19]、P[23]、P[25]、P[26]、P[27]、P[32]、P[34]、P[49]) 。
- Currently, a total of 12 G genotypes (G1-G6, G8-G12, G26) and 18 P genotypes (P [1] - P [8], P [11], P [13], P [19], P [23], P [25], P [26], P [27], P [32], P [34], P [49]) have been detected in pigs.
- G3、G4、G5、G9和G11被认为是猪中最常见的G基因型，通常与P[5]、P[6]、P[7]、P[13]和P[28]相互组合。
- G3, G4, G5, G9, and G11 are considered the most common G genotypes in pigs, typically combined with P [5], P [6], P [7], P [13], and P [28].

我国猪轮状病毒流行概况
Overview of Porcine Rotavirus Epidemic in China



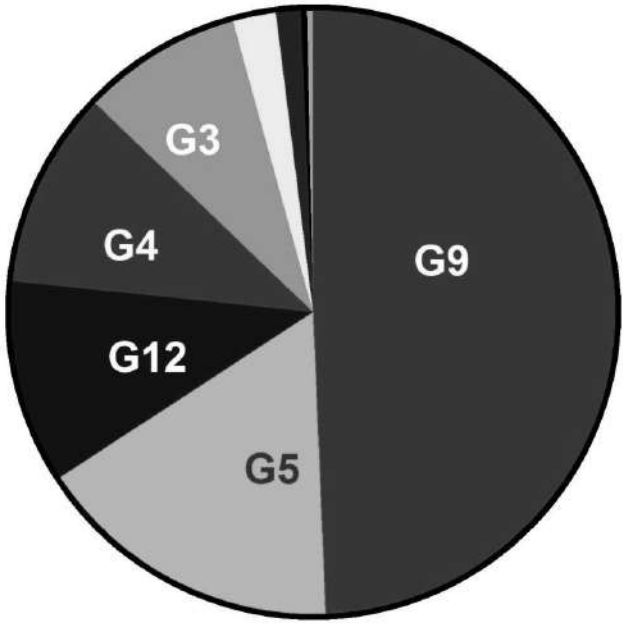


25768份腹泻样品，PoRV检测阳性率平均为86.09%；被检猪场80%为阳性。
25768 samples of diarrhea showed an average positive rate of 86.09% for PoRV detection; 80% of the tested pig farms tested positive.

排名前三为：G9（56.55%），G5（14.48%），G1（8.97%）。
The top three are G9 (56.55%), G5 (14.48%), and G1 (8.97%).

（Mengli Qiao et al., 2024）

我国A群猪轮状病毒G基因型（PoRV A VP7）
Group A porcine rotavirus G genotype (PoRV A VP7) in China



VP7

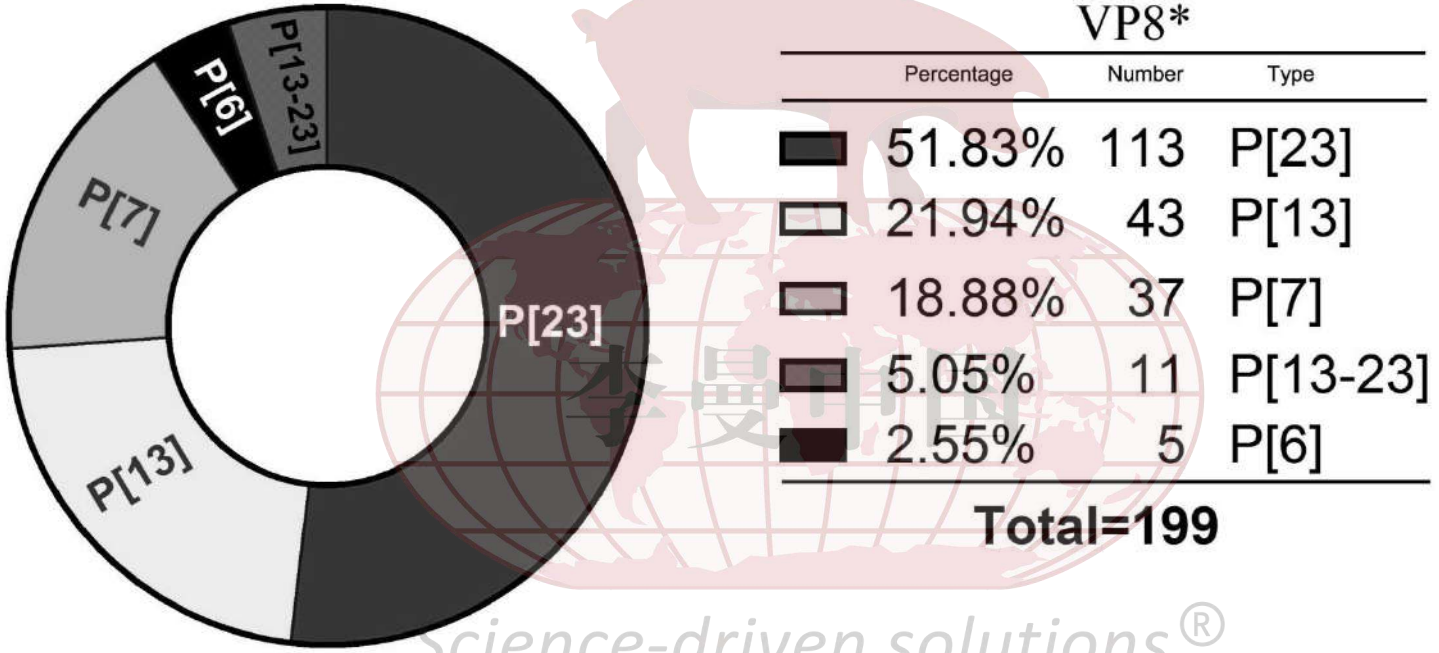
Percentage	Number	Type
49.34%	150	G9
17.00%	51	G5
12.00%	36	G12
9.00%	27	G4
8.67%	26	G3
2.33%	7	G1
1.33%	4	G2
0.33%	1	G26
0.33%	1	G11

Total=307

Tips：提示：
1.G9,G5,G12,G4 and G3 are the main genotype;
1.G9、G5、G12、G4和G3是主要的基因型
2.Mixed infection with at least two genotypes;
2.至少有两种基因型的混合感染

Tips：提示：
1.G9, G5,G12,G4 and G3 are the main genotype;
1.G9、G5、G12、G4和G3是主要的基因型
2.Mixed infection with at least two genotypes;
2.至少有两种基因型的混合感染

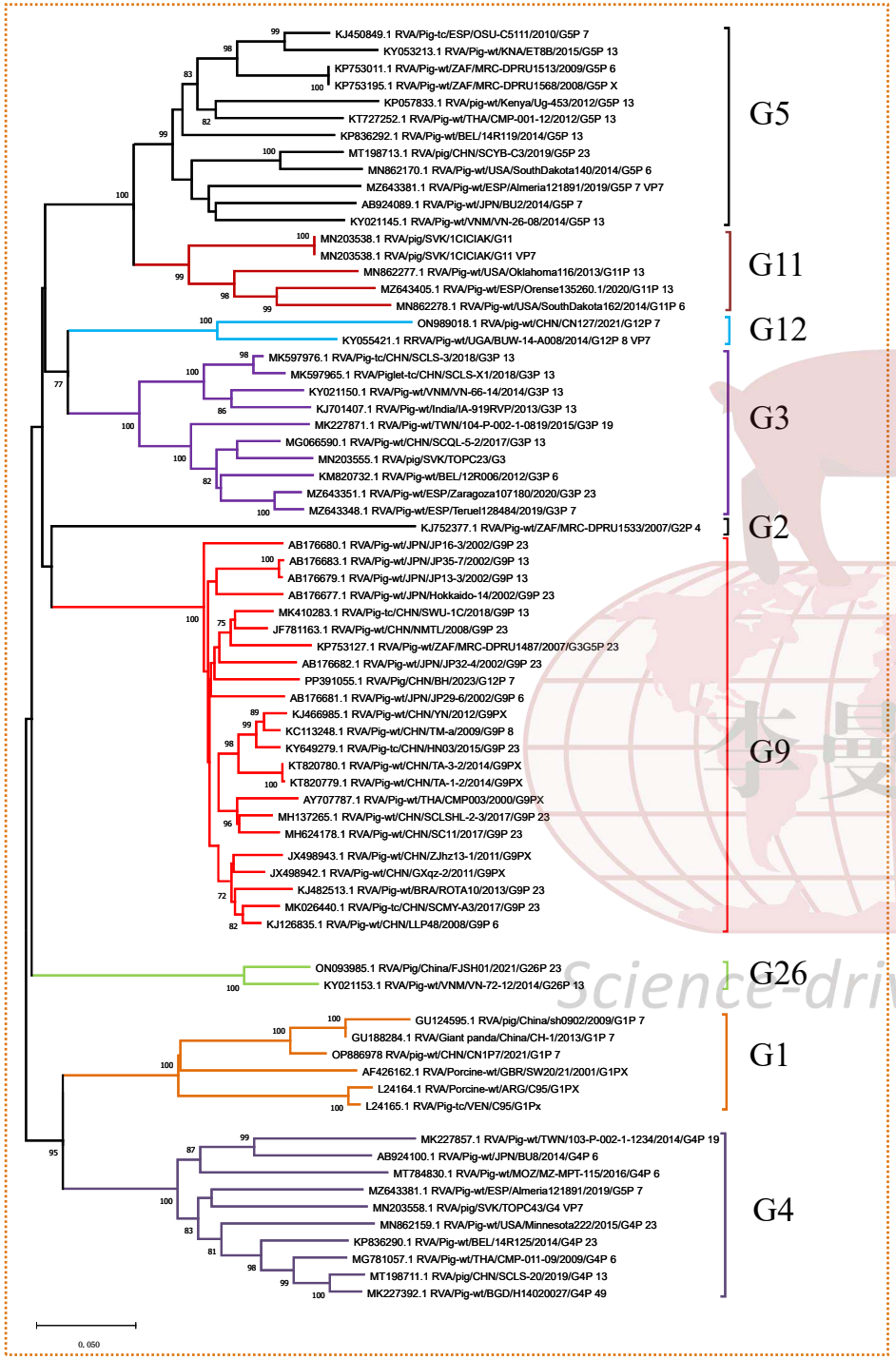
A群猪轮状病毒P基因型（PoRV A VP4）检测结果
Detection results of P genotype (PoRV A VP4) of porcine rotavirus in Group A

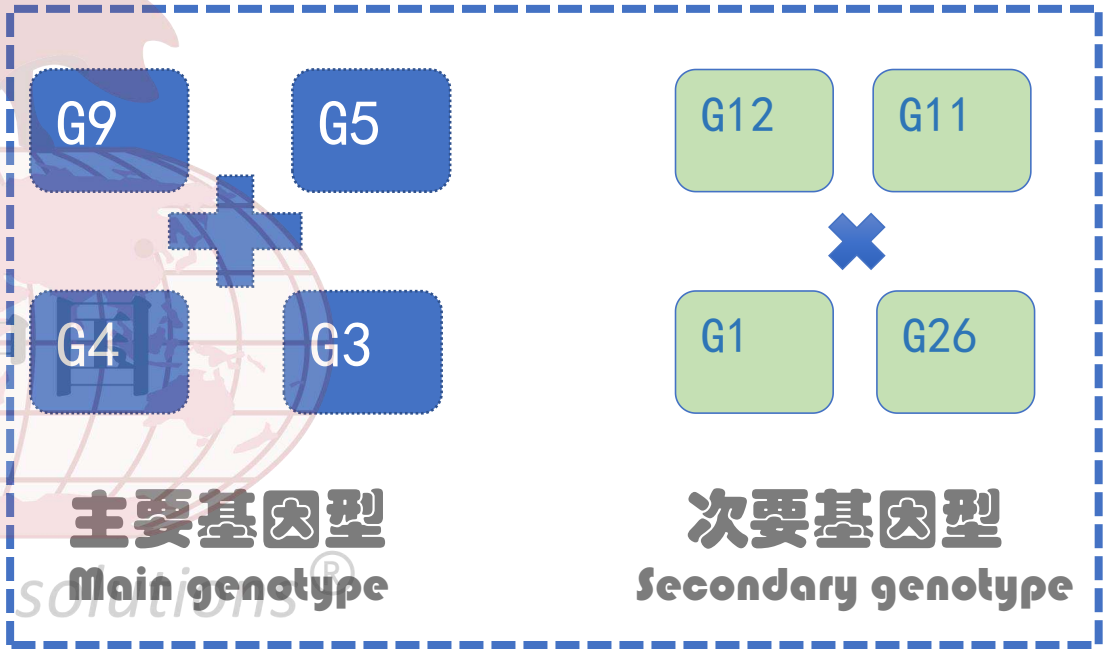


根据P基因型检测结果，P[23], P[13] and P[7] 为我国主要的基因型；
According to the results of P genotype testing, P [23], P [13], and P [7] are the main genotypes in China;

A 群轮状病毒

Group A rotavirus





中国PoRV各主要基因型占比

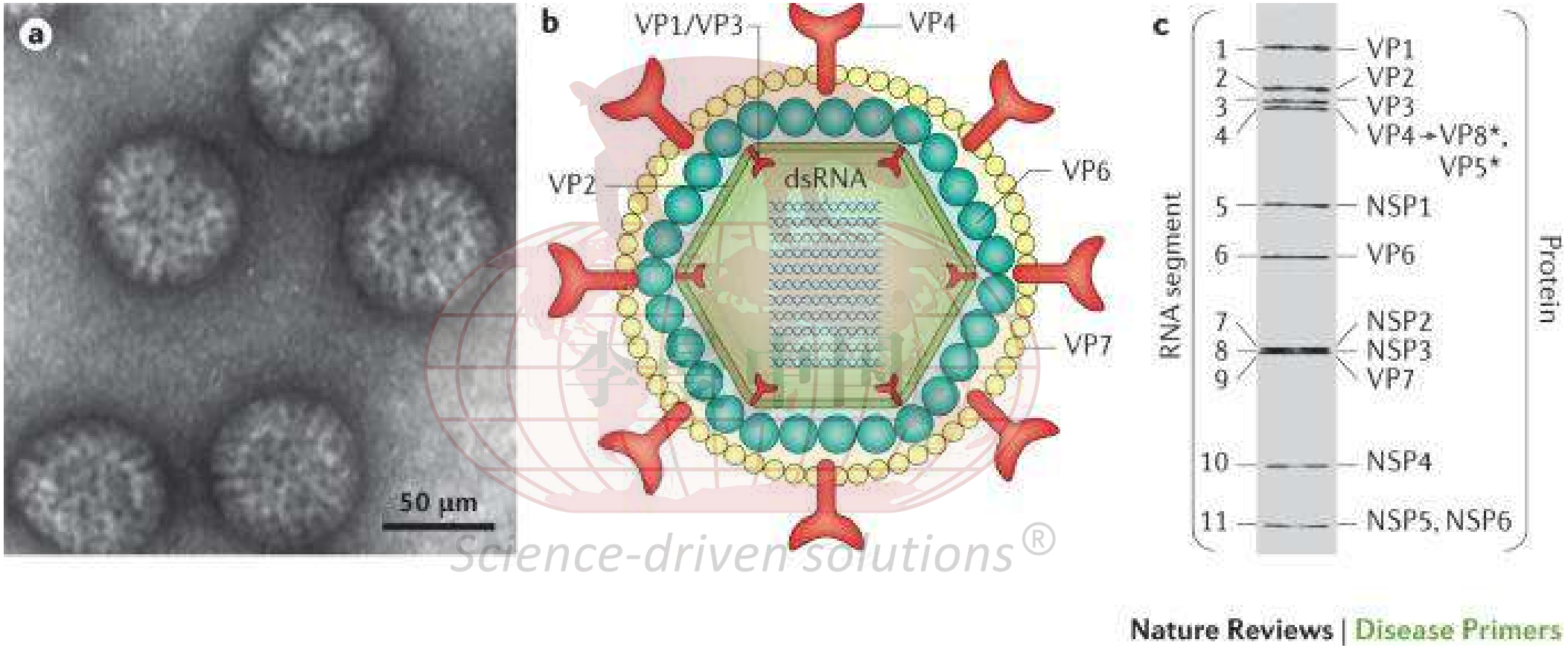
Proportion of major genotypes of PoRV in China

针对当前G5、G9 P[23]
Regarding the current G5 and G9P [23]

同时覆盖其它基因型（G3、G4等）
Simultaneously covering other genotypes (G3, G4, etc.)

我国猪群中C型轮状病毒的感染
PoRV C VP7 and VP4

Virus	Number	Location
G6P[5]	6	成都\南京
G1P[5]	1	南京
G9P[X]	1	成都



Nature Reviews | Disease Primers

S—○ E. C◎／＼／／□◎⌓ ○↗↗,／Ⓛ
2017

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RVA、RVC群轮状病毒的血清型
Serotypes of rotavirus in RVA and RVC groups

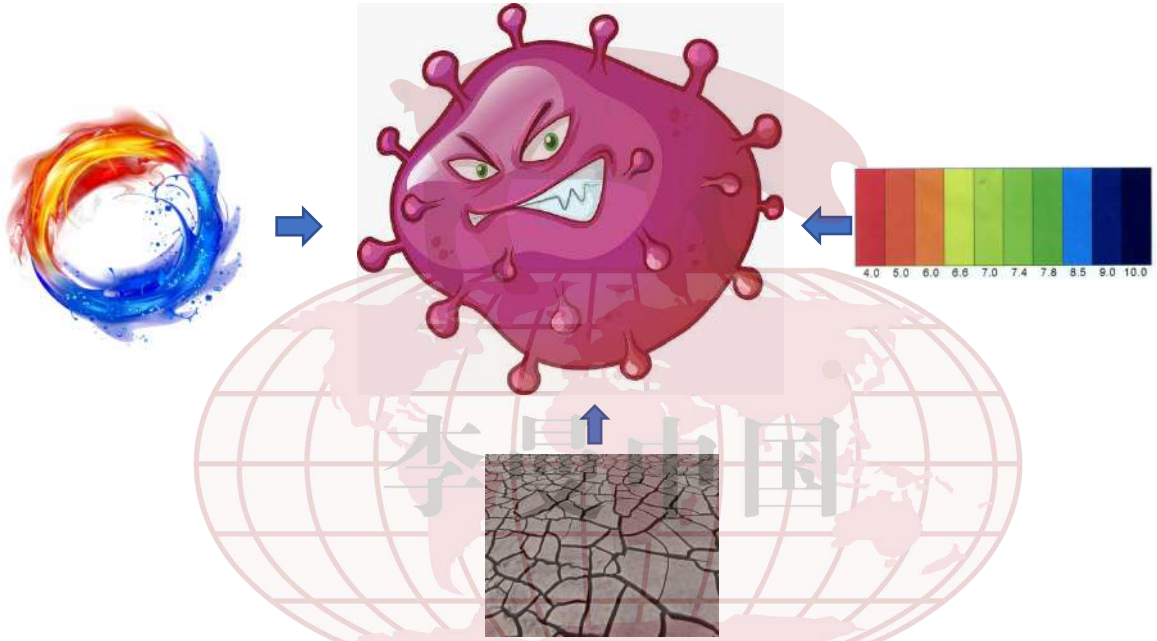
- 轮状病毒有10个抗原群：A、B----J；感染猪的有A、B、C、E、H
- Rotavirus has 10 antigen groups: A, B -- J; pigs infected with it have A, B, C, E, H

- A群轮状病毒：根据VP7分，有42个血清型，根据VP4分，有58个血清型
- Group A rotavirus: According to VP7 score, there are 42 serotypes, and according to VP4 score, there are 58 serotypes

- C群轮状病毒：根据VP7分，有9个血清型，根据VP4分，有7个血清型
- Group C rotavirus: According to VP7 score, there are 9 serotypes, and according to VP4 score, there are 7 serotypes

轮状病毒的理化特性
PoRV characteristics

Temperature
温度



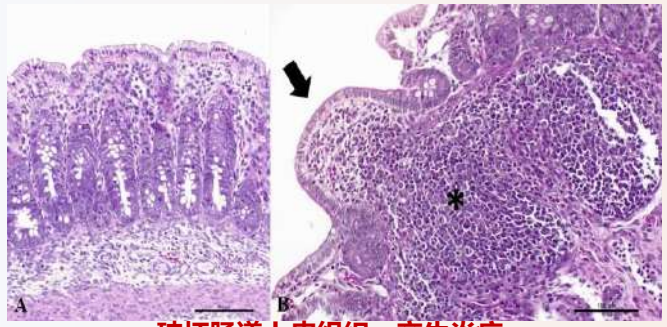
pH

High resistance to temperature, humidity and pH
对温度、湿度和pH值具有高耐受性
No loss for infectivity at 4°C, dryness
4°C干燥时无感染性损失
No significant change for infection with the season change
感染随季节变化无明显变化

主要内容 Contents

猪轮状病毒的危害及影响
The harm and impact of porcine rotavirus

PoRV的危害

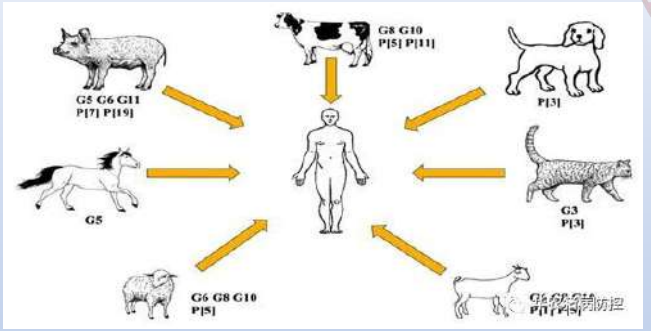


破坏肠道上皮组织，产生炎症
Destruction of intestinal epithelial tissue, resulting in inflammation

引起小猪腹泻、脱水，产生僵尸猪
Causing diarrhea and dehydration in piglets, resulting in zombie pigs

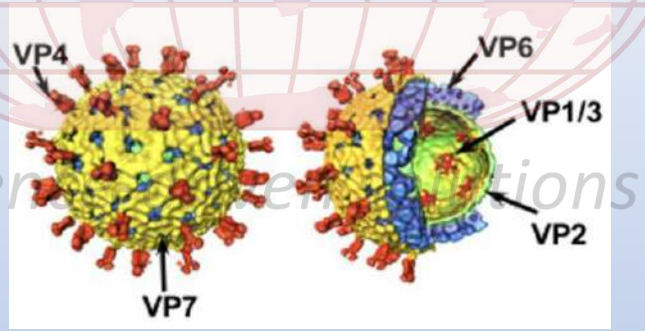
严重导致小猪死亡
Serious cause of piglet death

可以感染猪、牛、羊、马等多种幼龄哺乳动物，引起腹泻
It can infect various young mammals such as pigs, cows, sheep, and horses, causing diarrhea



传播范围广泛，可感染人
Widely spread and capable of infecting people

多血清群、多学清型、多基因型，容易发生突变
Multiple serum groups, multiple serotypes, and multiple genotypes are prone to mutations

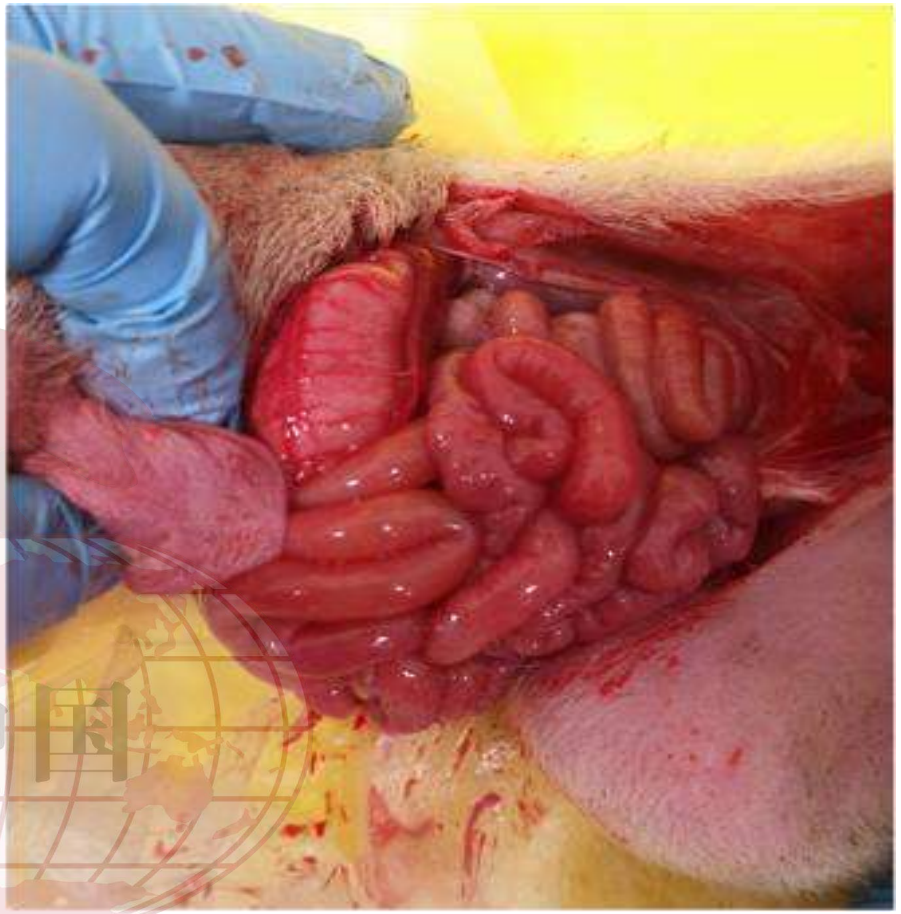


现有单价疫苗无法形成有效免疫保护
The existing monovalent vaccines cannot form effective immune protection

对环境有较强的抵抗力，摄入较小的病毒剂量即可感染
Has strong resistance to the environment and can be infected with small doses of virus

控制疾病的传播极为困难
Controlling the spread of diseases is extremely difficult

Miyabe FM et al., Scientific Reports, 2020



Morbidity ： day 1-7 piglet　　>80% 发病率：第1-7天仔猪>80%

Mortality ： **7%～20%**　　**死亡率：7%～20%**

Symptom : **Diahhrea and Emesis**　　**症状：腹泻和呕吐**

不同病毒性肠道病原的感染肠细胞类型
Types of intestinal cells infected by different viral intestinal pathogens

感染小肠上皮细胞

Infection of small intestinal epithelial cells

1型

- Coronavirus (TGEV)
- Rotavirus (Group A B C E H)

感染上皮与肠隐窝细胞

2型

Infection of epithelial and intestinal crypt cells

- Adenovirus 腺病毒
- Torovirus 环曲病毒

3型

- Coronavirus (PEDV) 冠状病毒（PEDV）

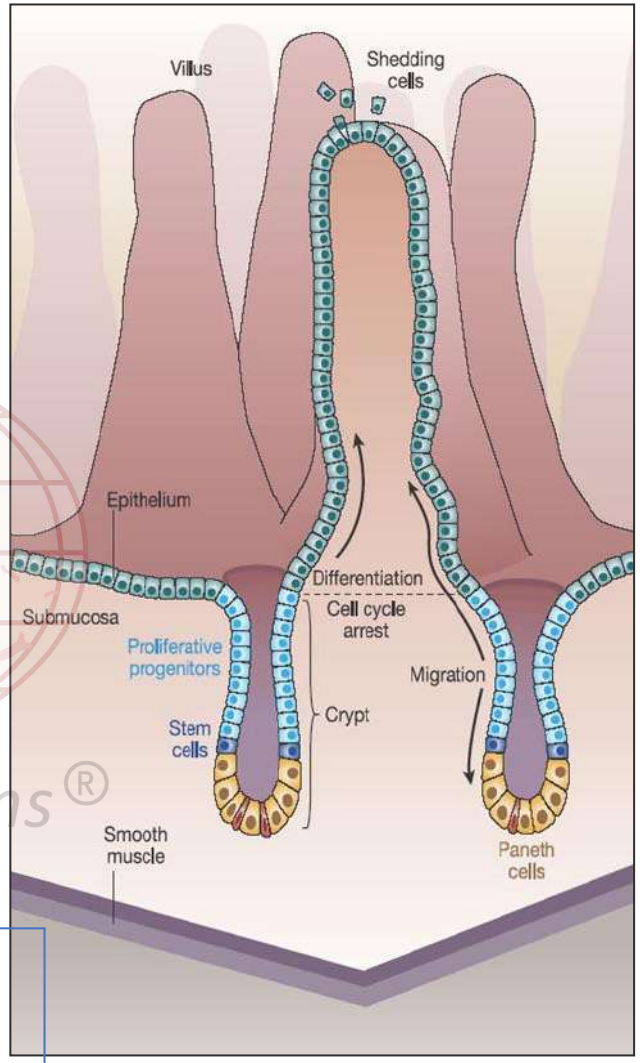
感染肠道隐窝细胞和淋巴细胞

Infection of intestinal crypt cells and lymphocytes

- Parvovirus 细小病毒
- Pestivirus (hog cholera virus, bovine viral diarrhea virus)
- 瘟病毒（猪瘟病毒、牛病毒性腹泻病毒）

感染肠道的病毒致病性 Pathogenicity of viruses infecting the intestine

What cells are infected and how? 哪些细胞被感染，如何感染?



Villus enterocytes 绒毛肠上皮细胞

- Digestion 消化
- Absoprtion 吸收

Crypt Enterocytes 隐肠细胞

- Stem cells --proliferation 干细胞——增殖
- Secretion 分泌物

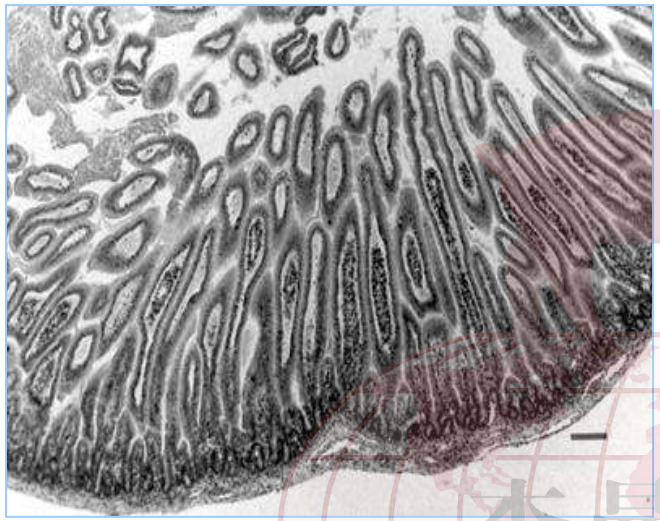
Lymphocytes/APCs 淋巴细胞/APC

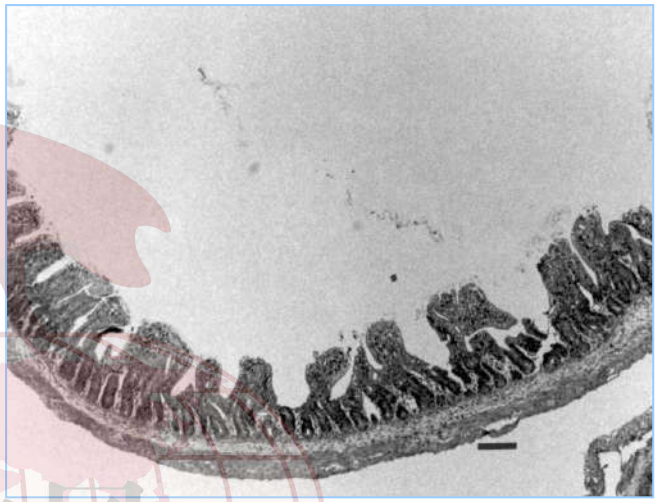
- Immunity 免疫

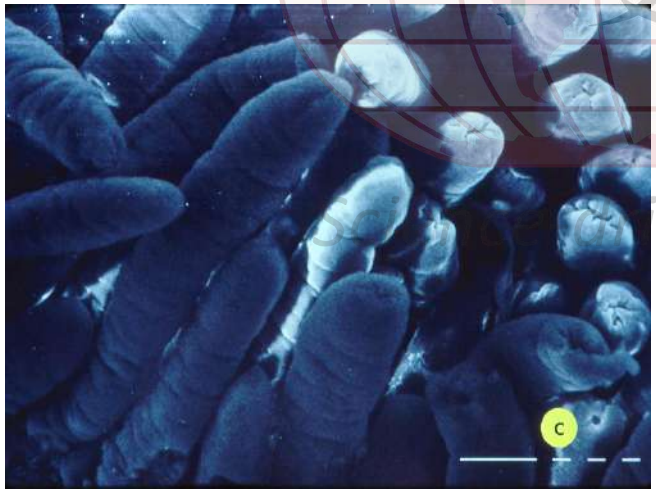
Crypt Villous tip transit time longer in younger vs older animals

与老年动物相比，年轻动物的隐窝绒毛尖端传输时间更长

轮状病毒对肠道的损伤 Rotavirus induced damage to the intestine







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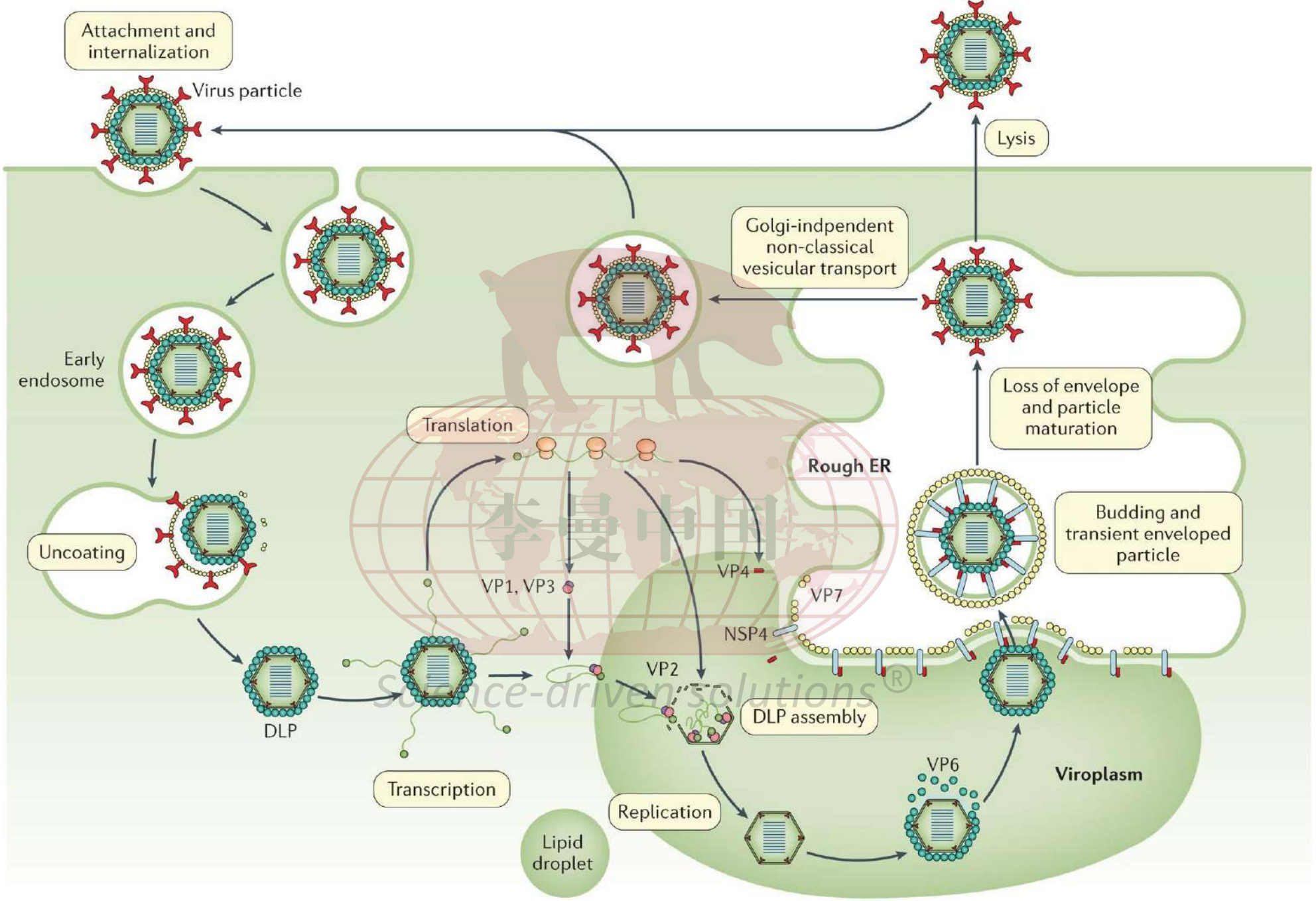
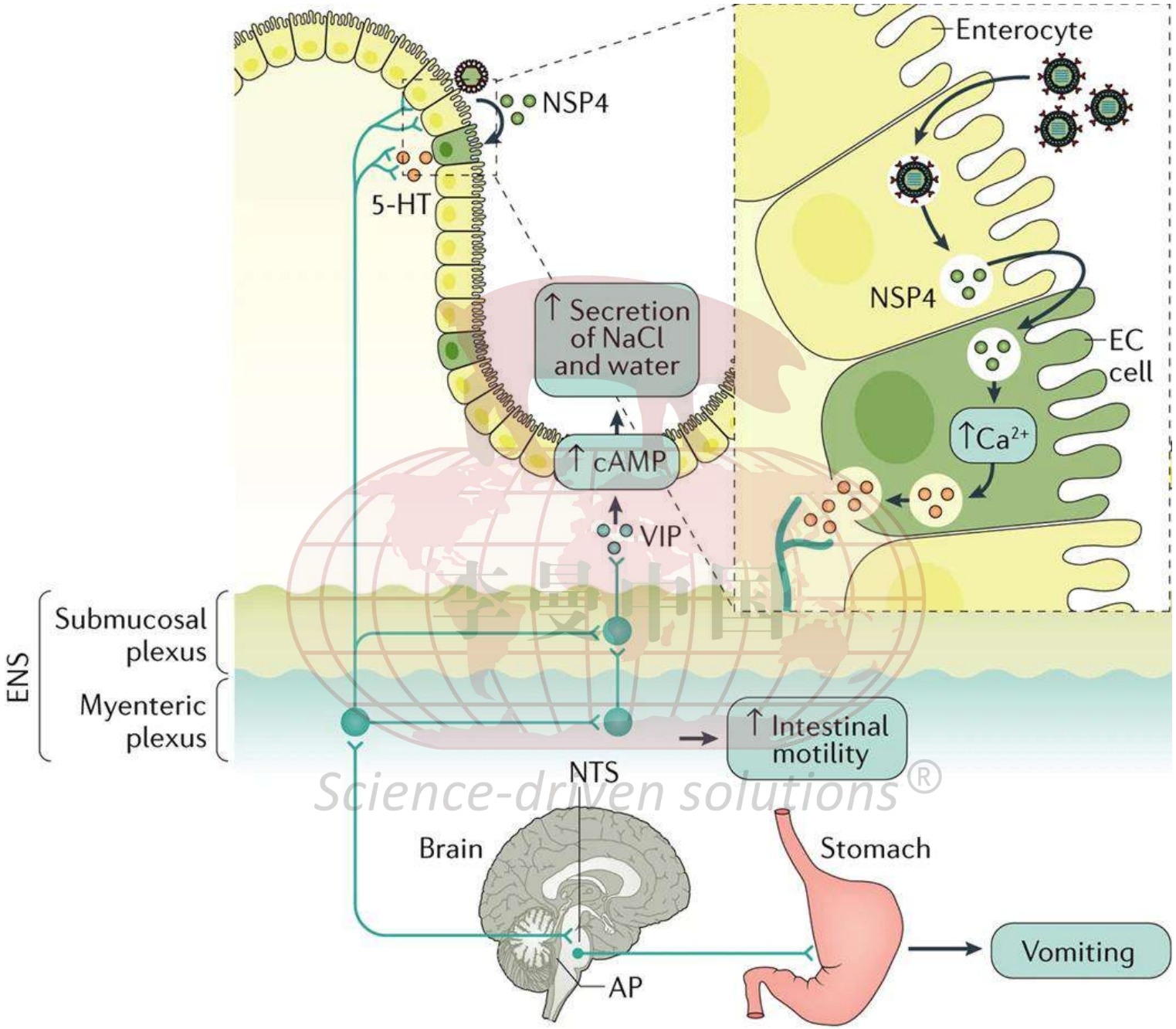
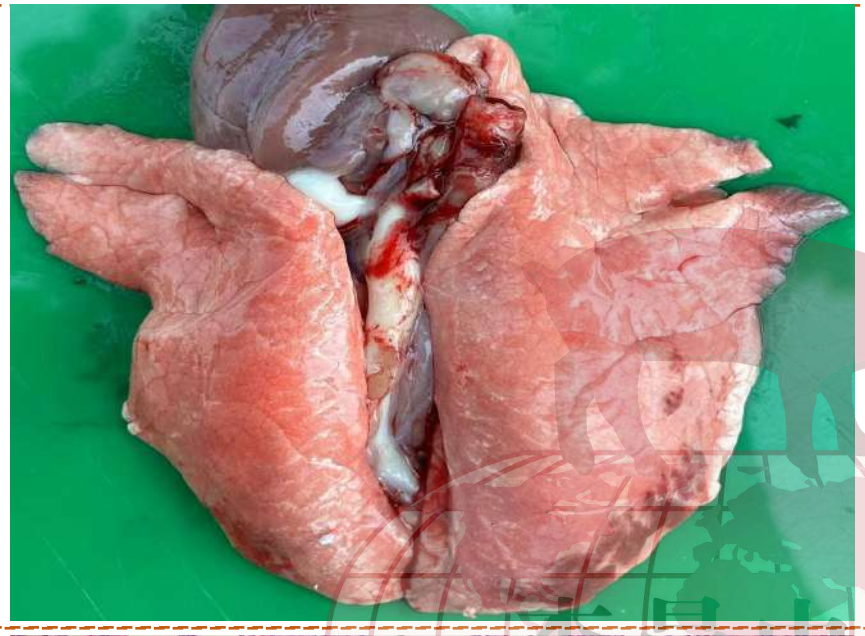
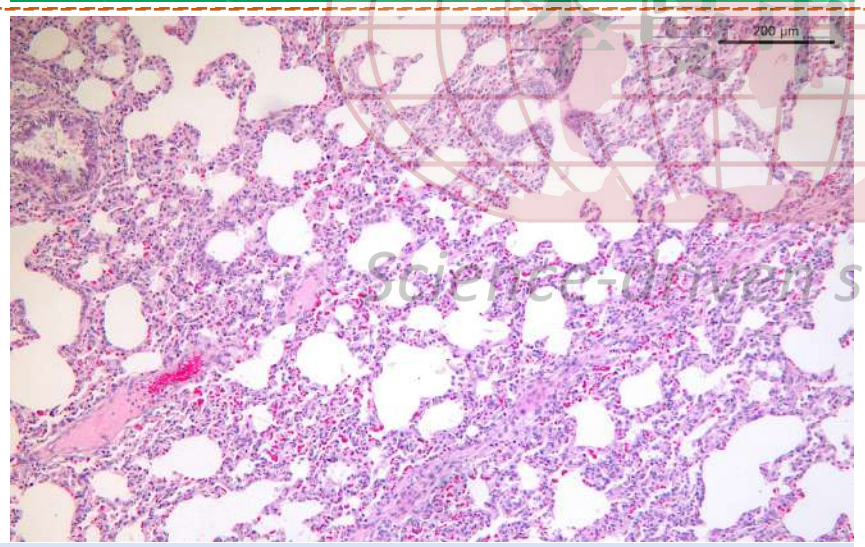
LINDA SAIF.

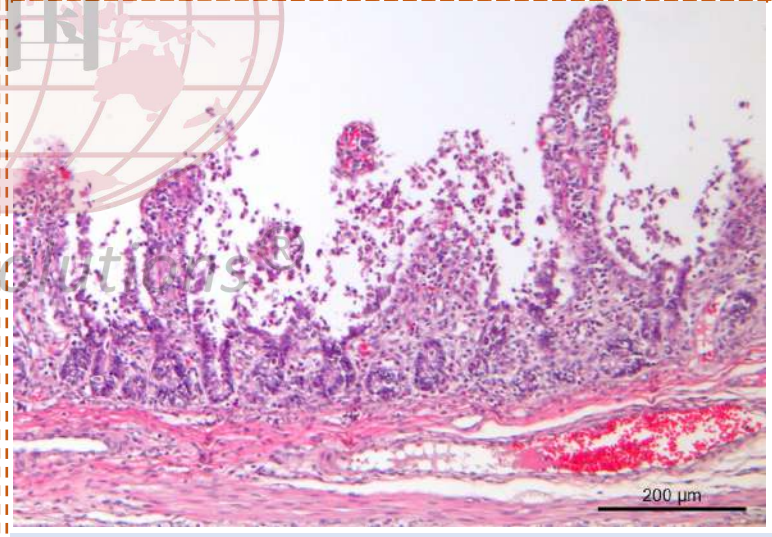




轮状病毒感染对肺脏的损伤 Lung damage caused by rotavirus infection







肺-广泛性的肺泡壁轻度增厚，间质纤维组织轻度增生
Widespread mild thickening of alveolar walls and mild proliferation of interstitial fibrous tissue in the lungs

空肠-绒毛萎缩，数量减少。
Intestinal villi atrophy and reduced quantity.

病毒攻击动物实验设计
Design of virus challenge animal experimental

Virus : $8*10^6$ $TCID_{50}$/ml 4 ml 5/group

MOCK : DMEM 4ml 3/group

Colostrum-deprived 1-day-old piglets

Orally inoculate

Observation

Euthanized at DPI 2

Postmortem anatomy

Evaluation of diarrhea degree

Shedding

Intestinal organ

Extra-/ Intestinal organ

HE

IHC

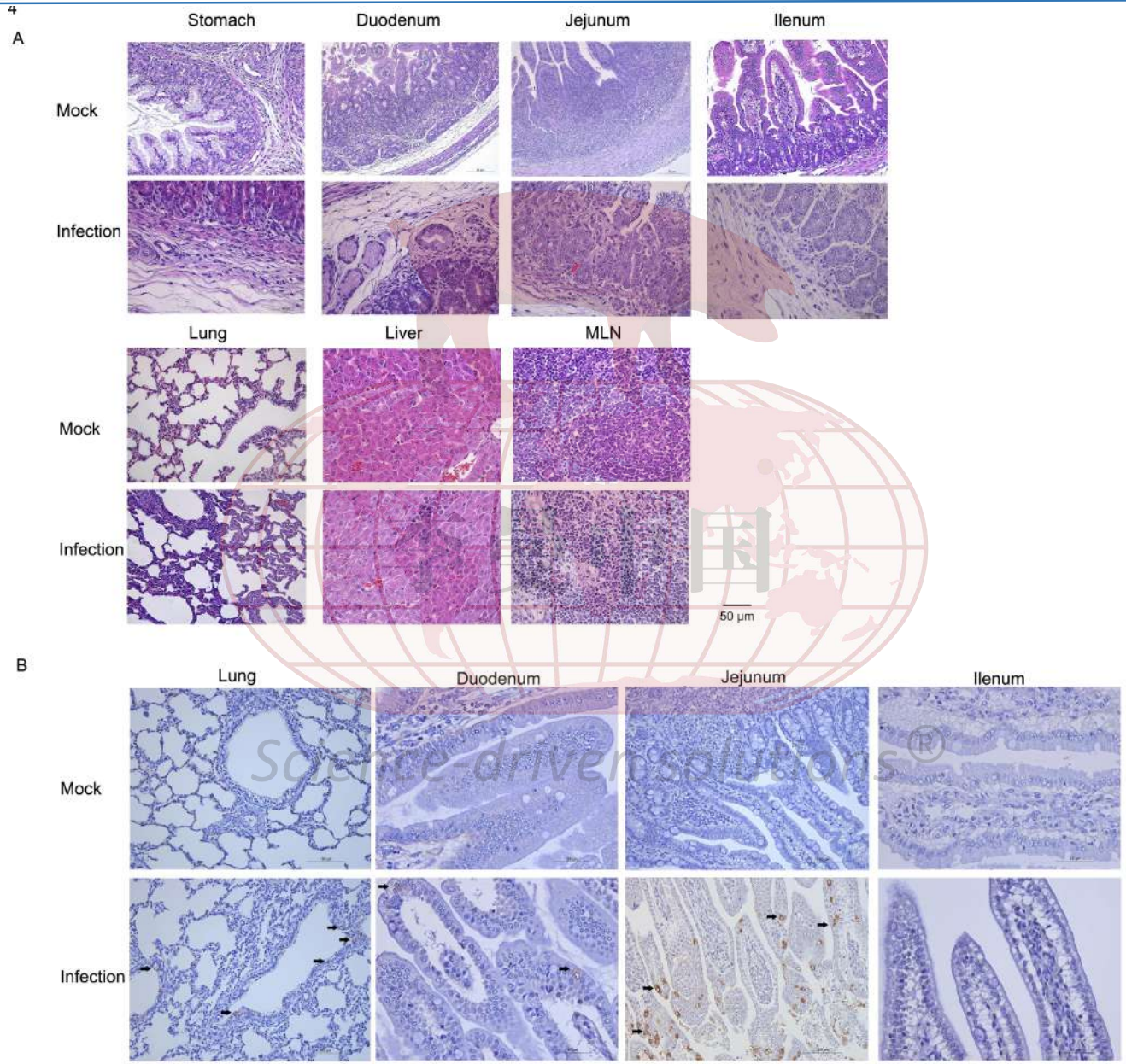
Virus load

Shedding

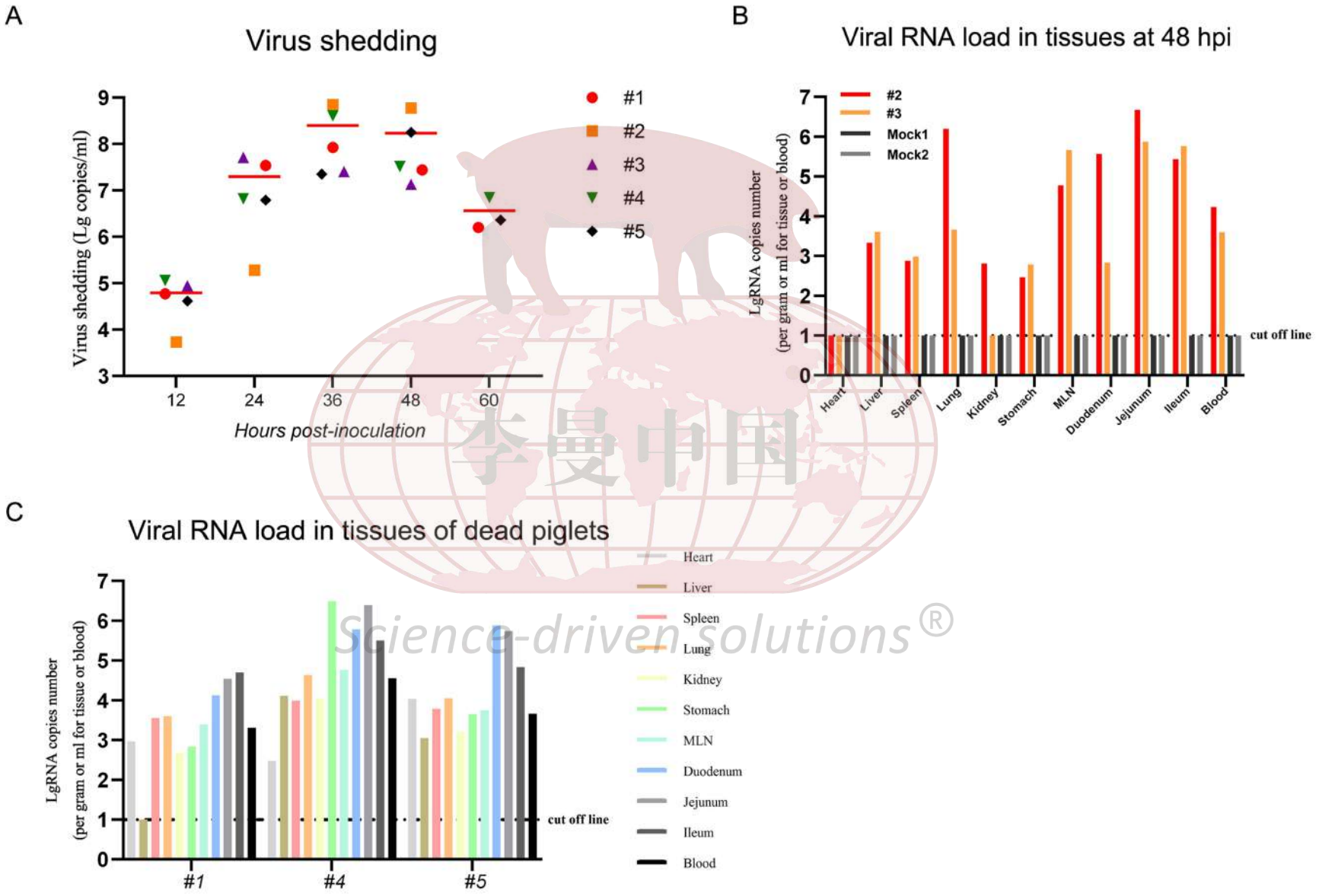
Shedding

Virus load

CN127的致病性 Pathogenicity about CN127



病毒载量 Virus loading about CN127



主要内容 Contents

01 Epidemic investigation of PoRV
轮状病毒及其流行

02 Pathogenicity of PoRV
轮状病毒的致病性及危害

03 **Strategies against PoRV infection**
猪轮状病毒的防控策略

轮状病毒的防控策略
Corrent strategies against PoRV

- 正确的诊断
- Correct diagnosis
- 疫苗的免疫（循环抗体）
- Immunization of vaccines (circulating antibodies)
- 对症治疗
- Symptomatic treatment
- 生物安全
- Bio-Safety

鉴别诊断是确诊的关键
The Key of difference of dignosis

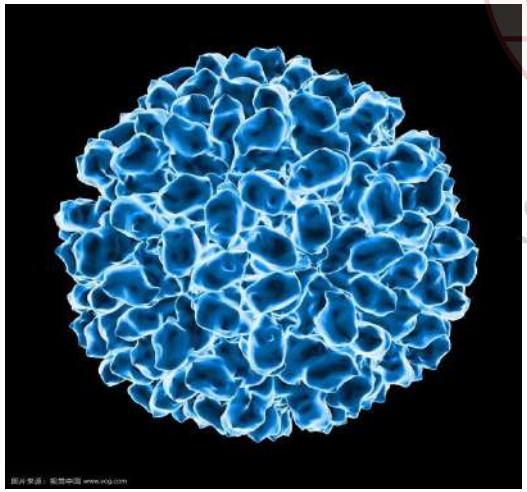
- 做好与哺乳动物弧肠孤病毒的鉴别诊断
- Perform differential diagnosis with mammalian enterovirus

- 做好与冠状病毒和细菌感染的鉴别诊断
- Perform differential diagnosis between coronavirus and bacterial infections

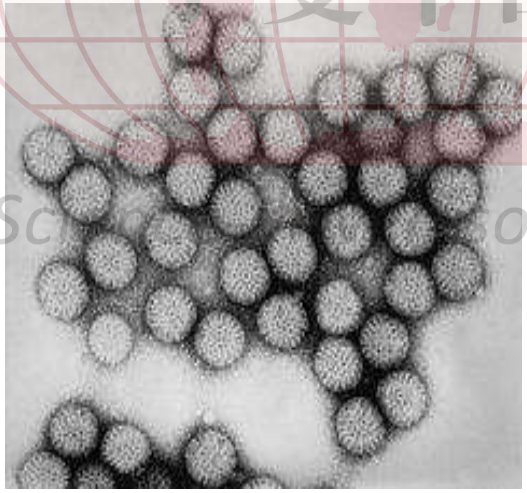
- 做好基因型的确定
- Determine the genotype accurately

哺乳动物呼肠孤病毒（Mammalian Reoviruses, **MRV)**

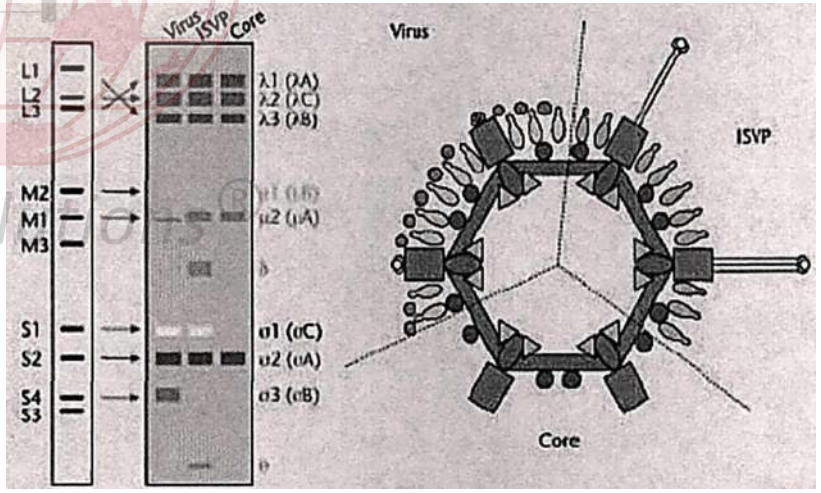
- 哺乳动物呼肠孤病毒（Mammalian Reoviruses, MRV）属于呼肠孤病毒科（Reoviridae），正呼肠孤病毒属成员。
- Mammalian Reoviruses (MRVs) belong to the Reoviridae family and are members of the genus Reoviridae.
- 病毒粒子具分11个节段的双链RNA病毒（L1-L3，M1-M3，S1-S4），呈球形，大小60～80纳米，20面体结构。
- The virus particles consist of 11 segments of double stranded RNA virus (L1-L3, M1-M3, S1-S4), which are spherical in shape, ranging in size from 60 to 80 nanometers, and have a 20 sided structure.
- 易感动物：马、牛、猪、绵羊、豚鼠、犬、猫、貂、禽类、蝙蝠以及人、黑猩猩和猴，导致呼吸道及消化道疾病。
- Vulnerable animals: horses, cows, pigs, sheep, guinea pigs, dogs, cats, minks, poultry, bats, as well as humans, chimpanzees, and monkeys, causing respiratory and digestive diseases.



模式图

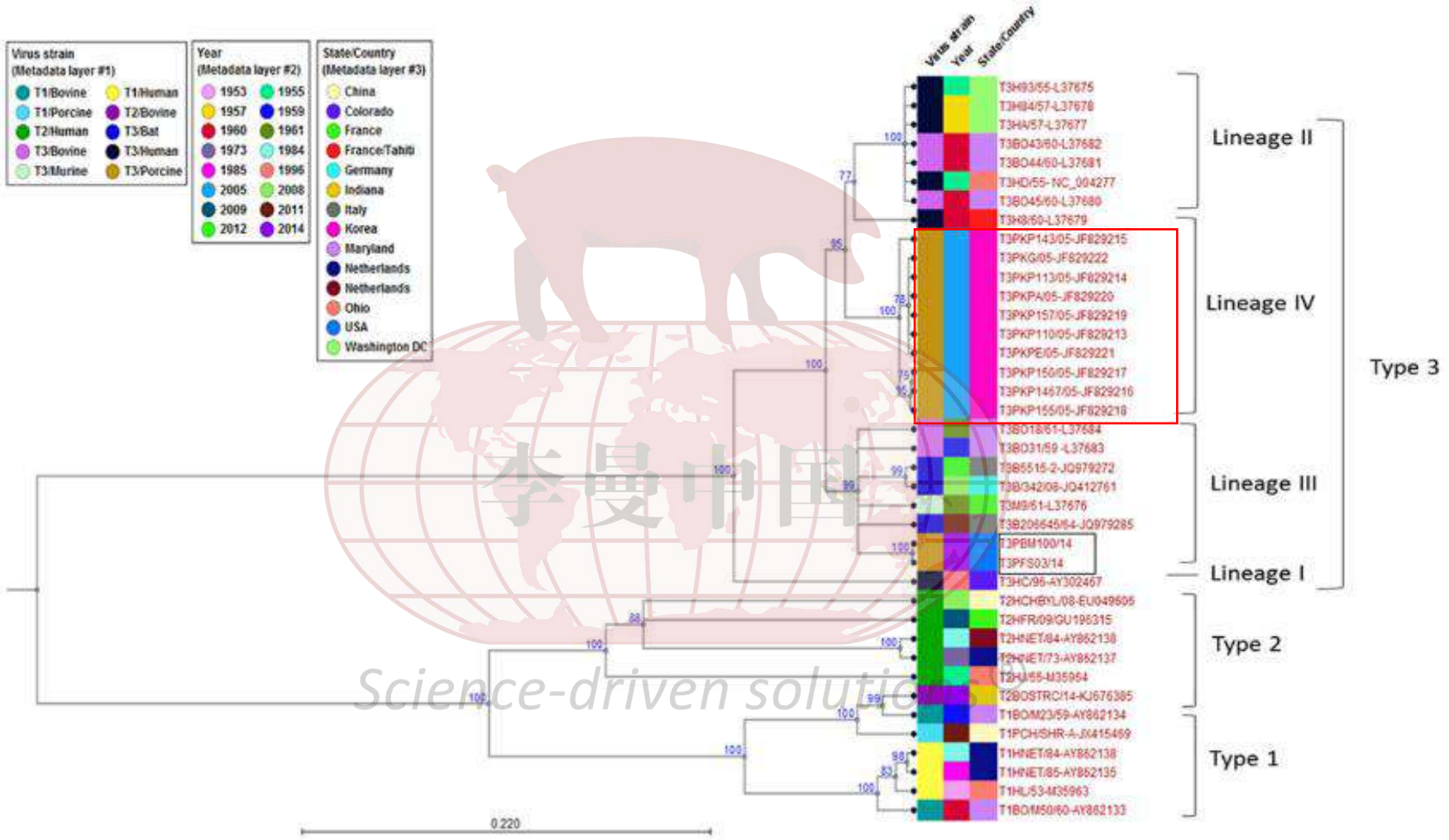


电镜图



结构示意图

新型正呼肠孤病毒的系统发育分析
Phylogenetic analysis of novel orthoreoviruses

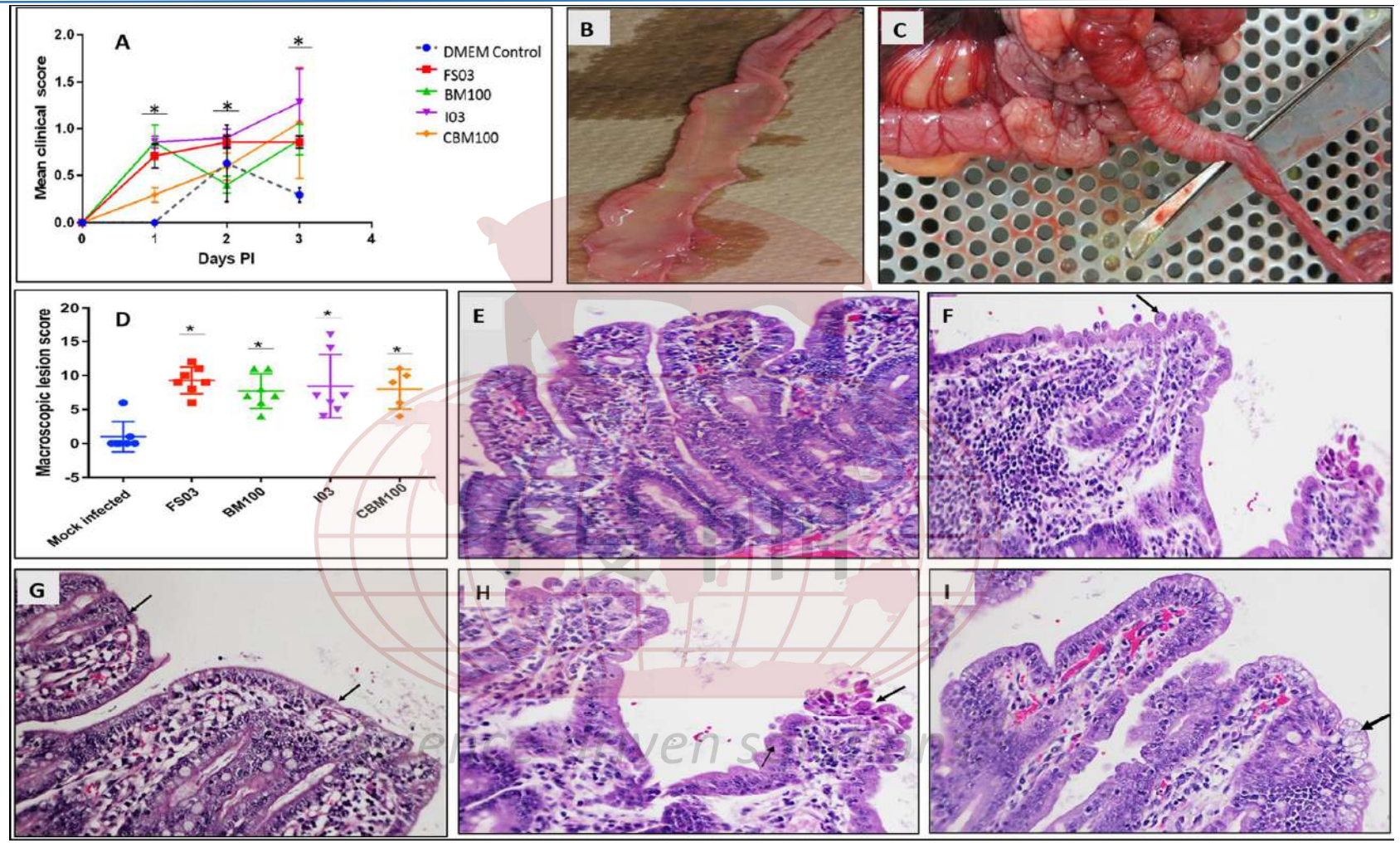


Athmaram Thimmasandra Narayanappa et al., mBio,2015

哺乳动物呼肠孤病毒主要分为三个亚型，其中具有致病性的主要集中在三型，而对猪产生致病性的也主要集中在三型

Mammalian reovirus is mainly divided into three subtypes, among which the pathogenic ones are mainly concentrated in type three, and those that cause pathogenicity to pigs are also mainly concentrated in type three

猪正呼肠孤病毒的致病性 Pathogenicity of porcine orthoreovirus

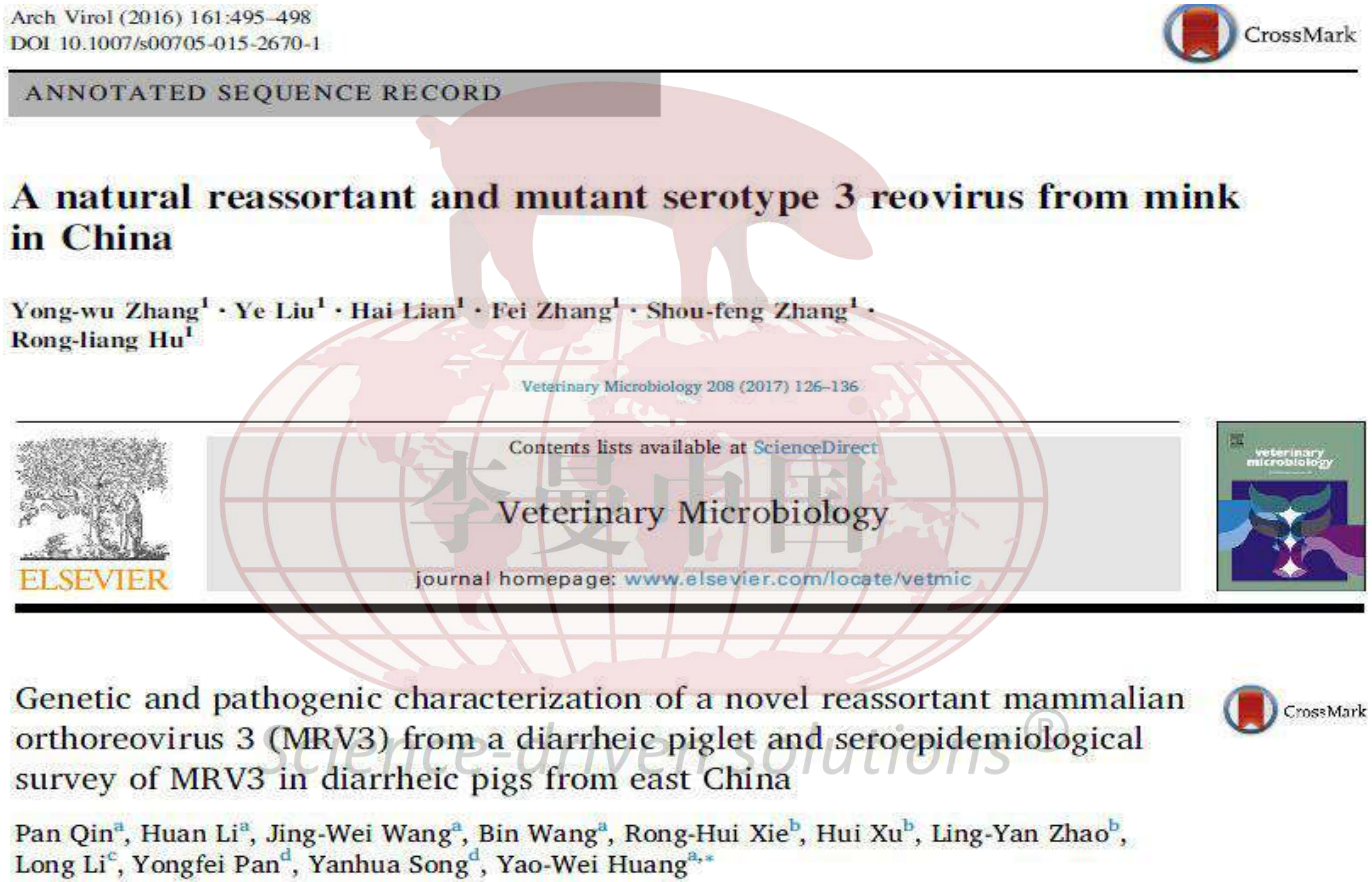


Athmaram Thimmasandra Narayanappa et al., mBio, 2015

Porcine orthoreovirus感染猪小肠上皮细胞，导致绒毛脱落及融合，同时可见绒毛上皮细胞合胞体产生，粘膜上皮细胞肿胀坏死，空泡化。

Porcine orhoreovirus infection of small intestinal epithelial cells in pigs leads to shedding and fusion of villi, as well as the formation of syncytia of villi epithelial cells, swelling and necrosis of mucosal epithelial cells, and vacuolization.

哺乳动物呼肠孤病毒（MRV）
Mammalian reovirus (MRV)



Arch Virol (2016) 161:495–498
DOI 10.1007/s00705-015-2670-1

CrossMark

ANNOTATED SEQUENCE RECORD

A natural reassortant and mutant serotype 3 reovirus from mink in China

Yong-wu Zhang[1] · Ye Liu[1] · Hai Lian[1] · Fei Zhang[1] · Shou-feng Zhang[1] · Rong-liang Hu[1]

Veterinary Microbiology 208 (2017) 126–136

Contents lists available at ScienceDirect

Veterinary Microbiology

journal homepage: www.elsevier.com/locate/vetmic

ELSEVIER

Genetic and pathogenic characterization of a novel reassortant mammalian orthoreovirus 3 (MRV3) from a diarrheic piglet and seroepidemiological survey of MRV3 in diarrheic pigs from east China

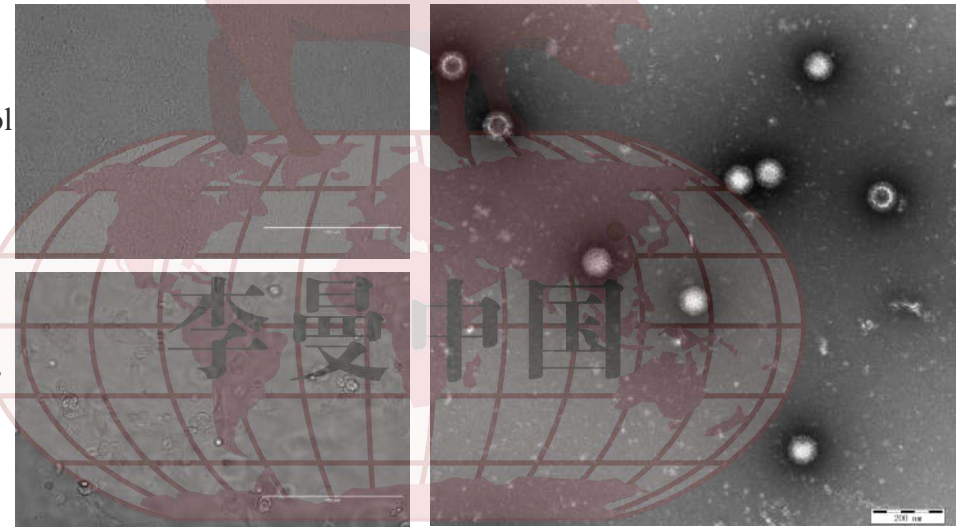
Pan Qin[a], Huan Li[a], Jing-Wei Wang[a], Bin Wang[a], Rong-Hui Xie[b], Hui Xu[b], Ling-Yan Zhao[b], Long Li[c], Yongfei Pan[d], Yanhua Song[d], Yao-Wei Huang[a,*]

- 在我国，2016年（Arch Virol. 161:495-498）和2017年（Vet Microbiol. 208:126-136.）也先后出现MRV3报道。
- In China, in 2016 (Arch Virol. 161:495-498) and 2017 (Vet Microbiol. 208:126-136.) MRV3 reports have also appeared successively.

猪呼肠孤病毒的分离与致病性
Isolation and pathogenicity of porcine reovirus

Control

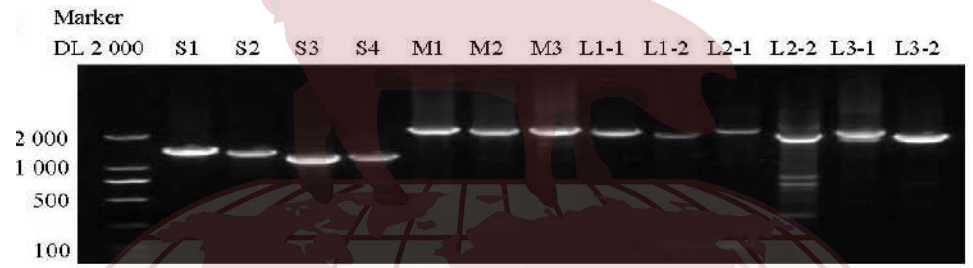
MRV HLJYC2017



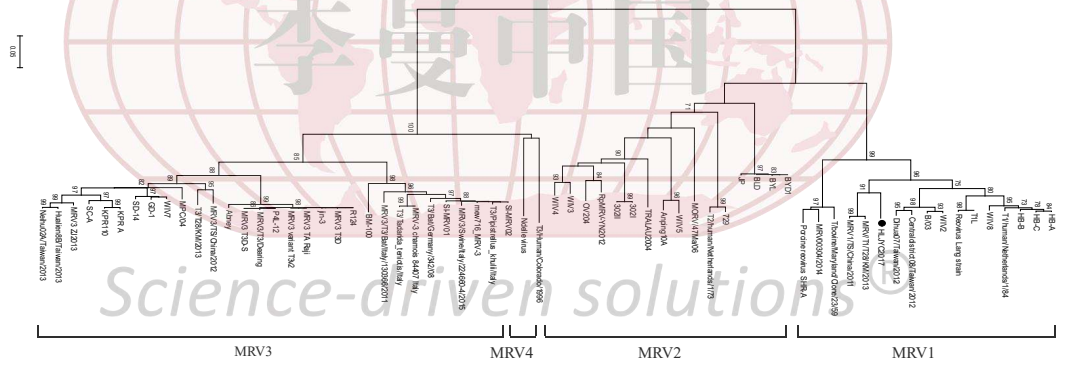
细胞病变　　电镜结果

- **MRV HLJYC2017 分离与鉴定**
- **Isolation and Identification of MRV HLJYC2017**

猪呼肠孤病毒的分离与致病性
Isolation and pathogenicity of porcine reovirus



MRV HLJYC2017 基因组扩增 MRV HLJYC2017 genome amplification

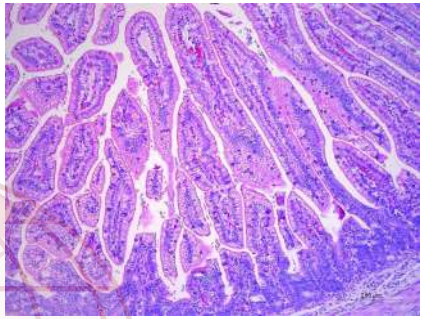


MRV HLJYC2017 进化树分析
Evolutionary Tree Analysis of MRV HLJYC2017

猪呼肠孤病毒的致病性
Pathogenicity of Porcine reovirus

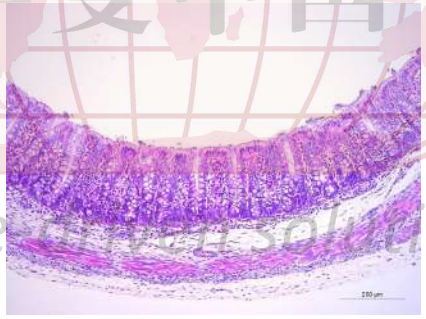
十二指肠 Duodenum

空肠 Jejunum

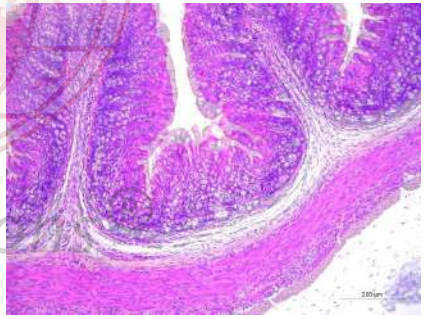


回肠 Ileum

盲肠 Cecum



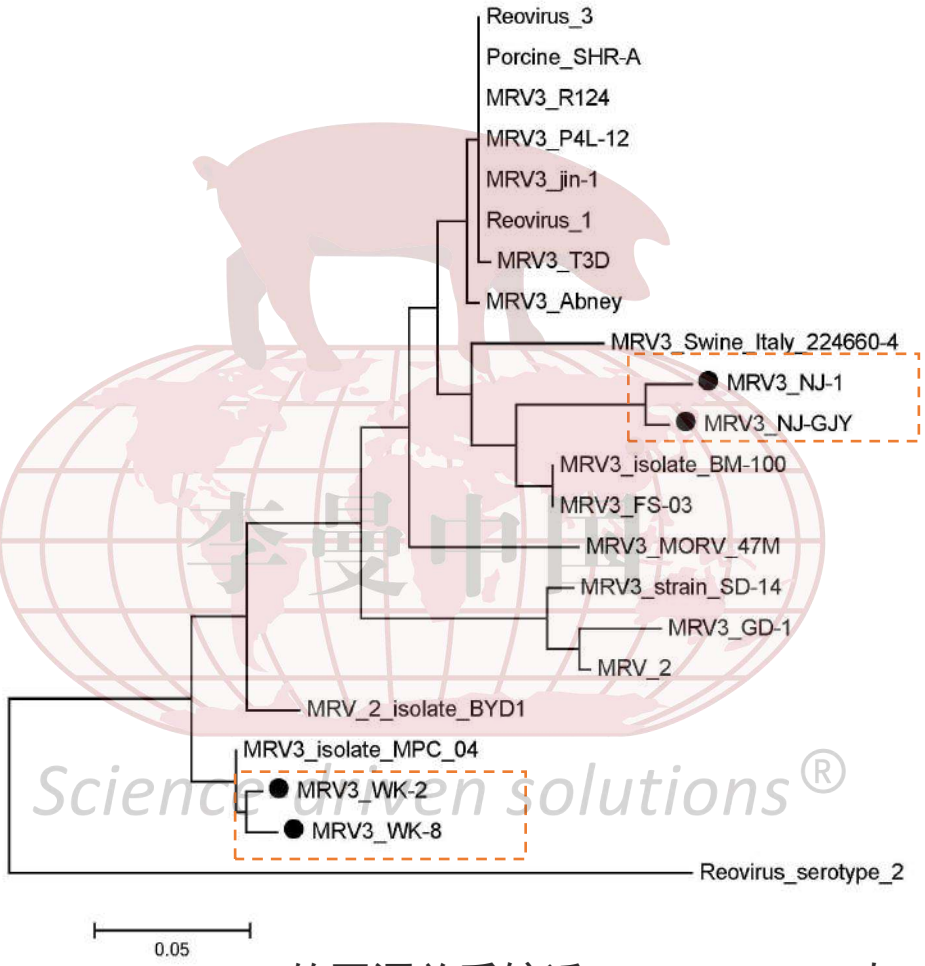
结肠 Colon



直肠 Rectum

- 病理变化：肠道无明显变化
- Pathological changes: No significant changes in the intestine

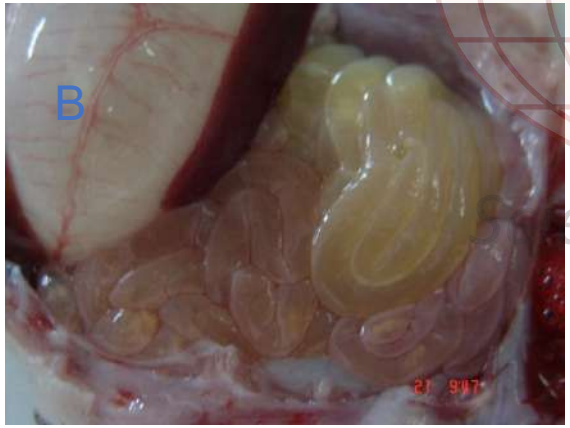
中国分离株MRV L1部分基因进化树
Evolutionary tree of partial genes of MRV L1 isolated from China

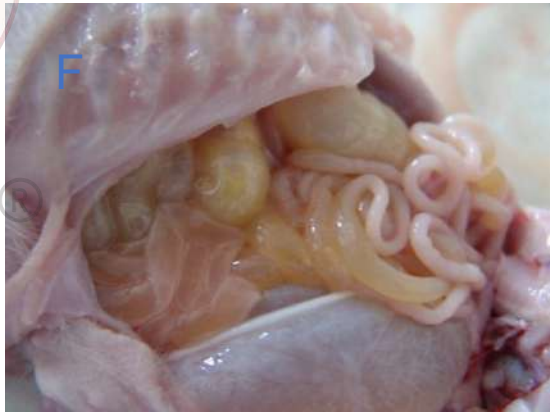


- ４株分离病毒中NJ-GJY, NJ-1与MRV3 BM-100的同源关系较近，WK-2, WK-8与MRV3 MPC04亲缘关系较近
- The homologous relationship between NJ-GJY, NJ-1, and MRV3 BM-100 among the four isolated viruses is relatively close, while WK-2, WK-8 are closely related to MRV3 MPC04

做好与猪冠状病毒的鉴别诊断

Perform differential diagnosis with porcine coronavirus

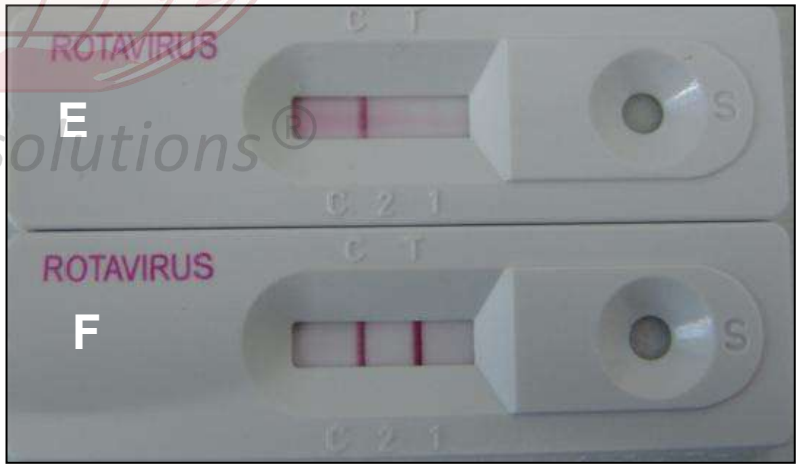




A,B:TGE　　C,D:PED　E,F:PoRV

免疫胶体金检测TGE、PED和PRV

Immunocolloidal gold detection for TGE, PED, and PRV



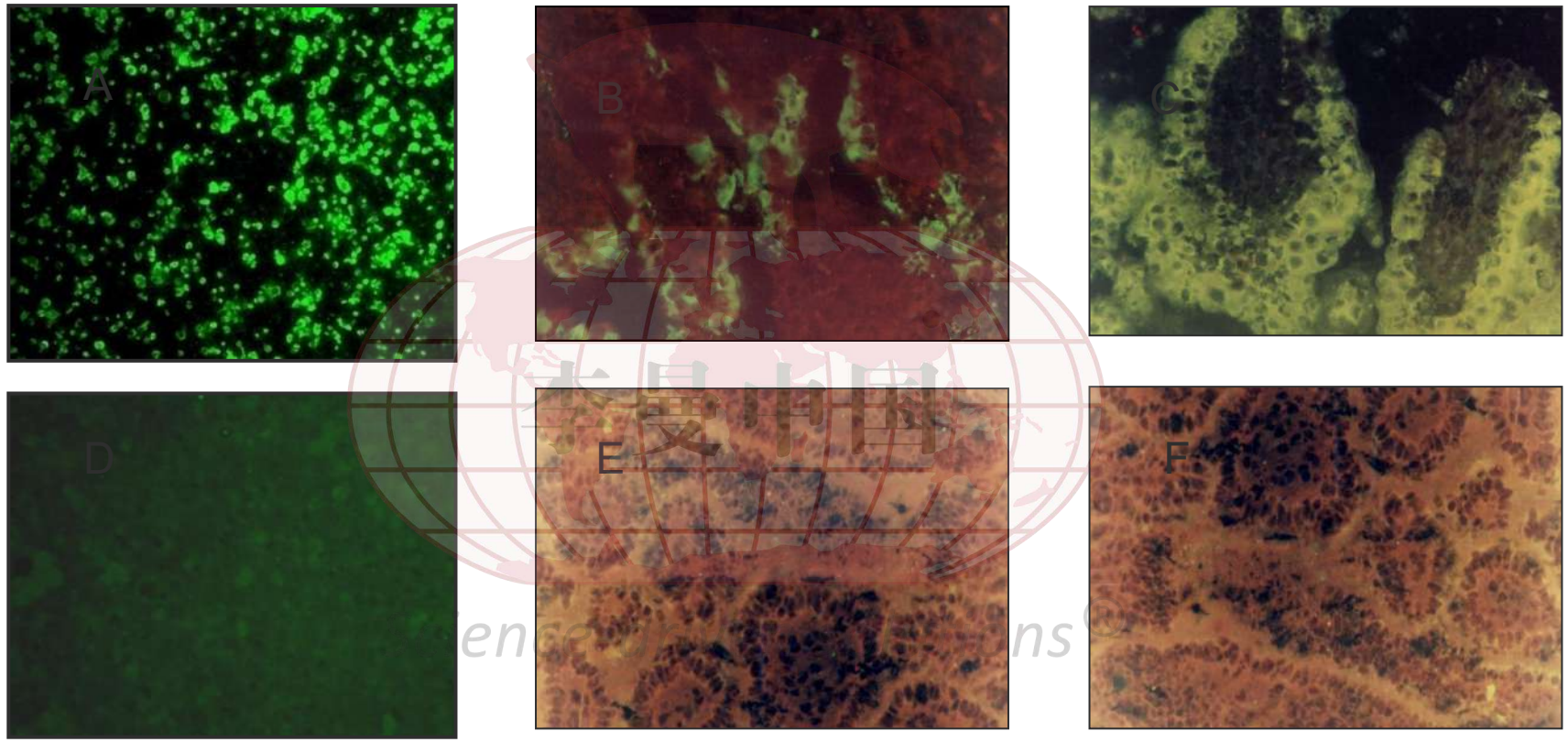
A:PED阴性　C:TGE阴性

B:PED阳性　D:TGE阳性

E:PRV阳性　F:PRV阴性

免疫荧光检测 PRV，TGE ，PED抗原

Immunofluorescence detection of PRV, TGE, PED antigens



A：PRV阳性 B：TGE 阳性 C：PED阳性

D：PRV阴性 E：TGE 阴性 F：PED 阴性

PCR方法鉴别TGE,PED,PRV

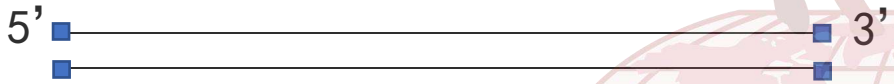
PCR method for identifying TGE, PED, PRV

PED RT-PCR　　TGE RT- PCR　　PRV RT-PCR

VP7和VP4基因PCR方法的建立及其基因型分析

Establishing of VP7 and VP4 gene PCR method and analysis of its genetype

VP7



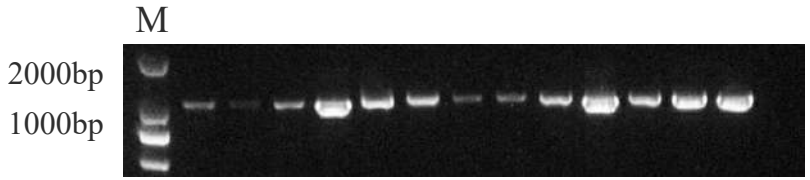
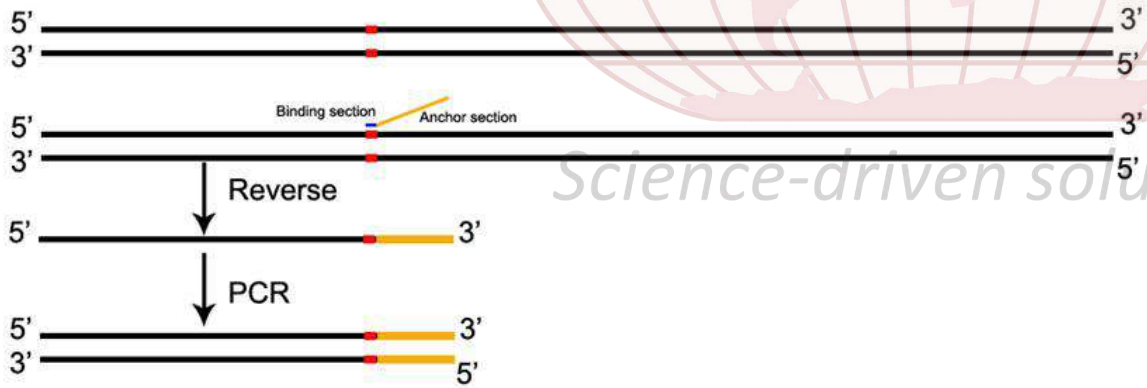
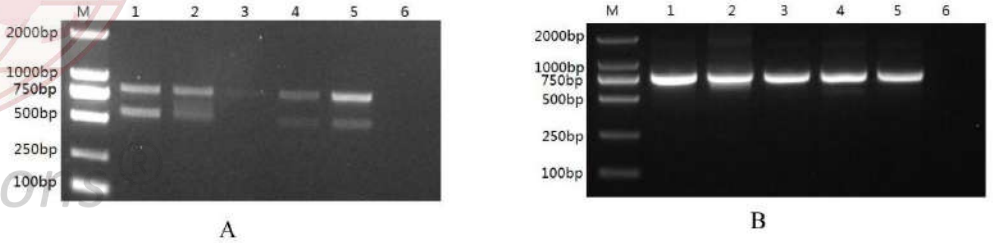


Fig.1 Identification of VP7 by PCR

图1 PCR扩增VP7基因

VP4





M :DNA Marker; 1:G9P[23] strain NMTL, 2:G3P[2] strain SA11, 3: G5P[23] strain 523-802, 4: G1P[7] strain 17-802, 5: G12P[7] strain 127-702; A: First round PCR; B: Second round PCR

Fig. 2 Identification of VP4 by PCR

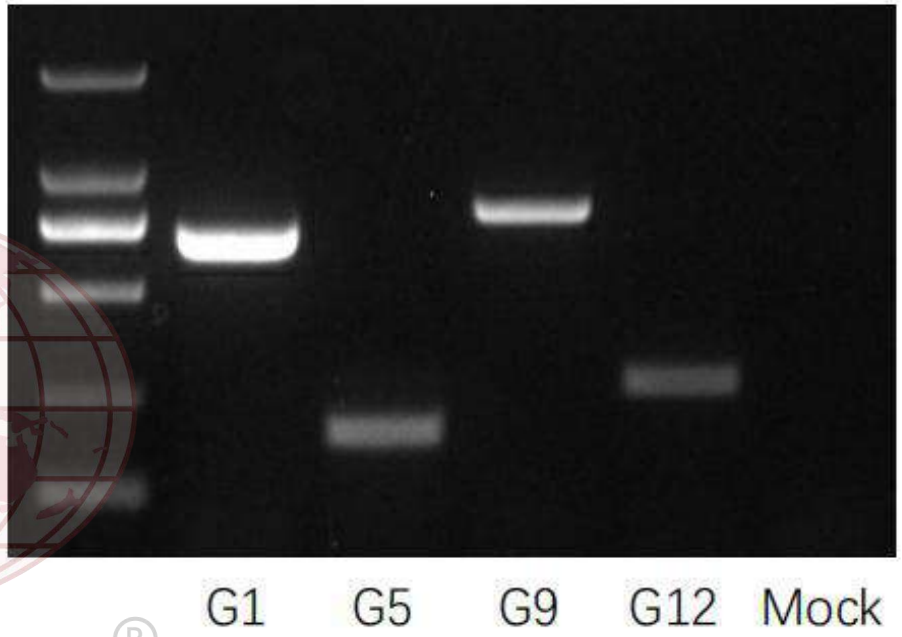
图 2 巢式 PCR 扩增 VP4 结果

基因型的确定
Identification of G type

Passage and adaptation
传代和适应

G1P[7]、G12P[7]、
G9P[23]、G5P[23]

$>10^8$ $TCID_{50}$/ml



Identification of VP7 by PCR
VP7的PCR鉴定

轮状病毒的防控策略
Corrent strategies against PoRV

- 正确的诊断
- Correct diagnosis

- 疫苗（抗原）的免疫及驯化（循环抗体）
- Immunization and domestication of vaccines (antigens) (circulating antibodies)

- 对症治疗
- Symptomatic treatment

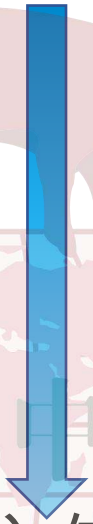
- 生物安全
- Bio-Safety

我国猪的G5型轮状病毒在应用疫苗前后阳性检出率

Positive detection rate of G5 rotavirus in pigs in China before and after vaccine application

2013　G5 29.4%

2023　G5 17%

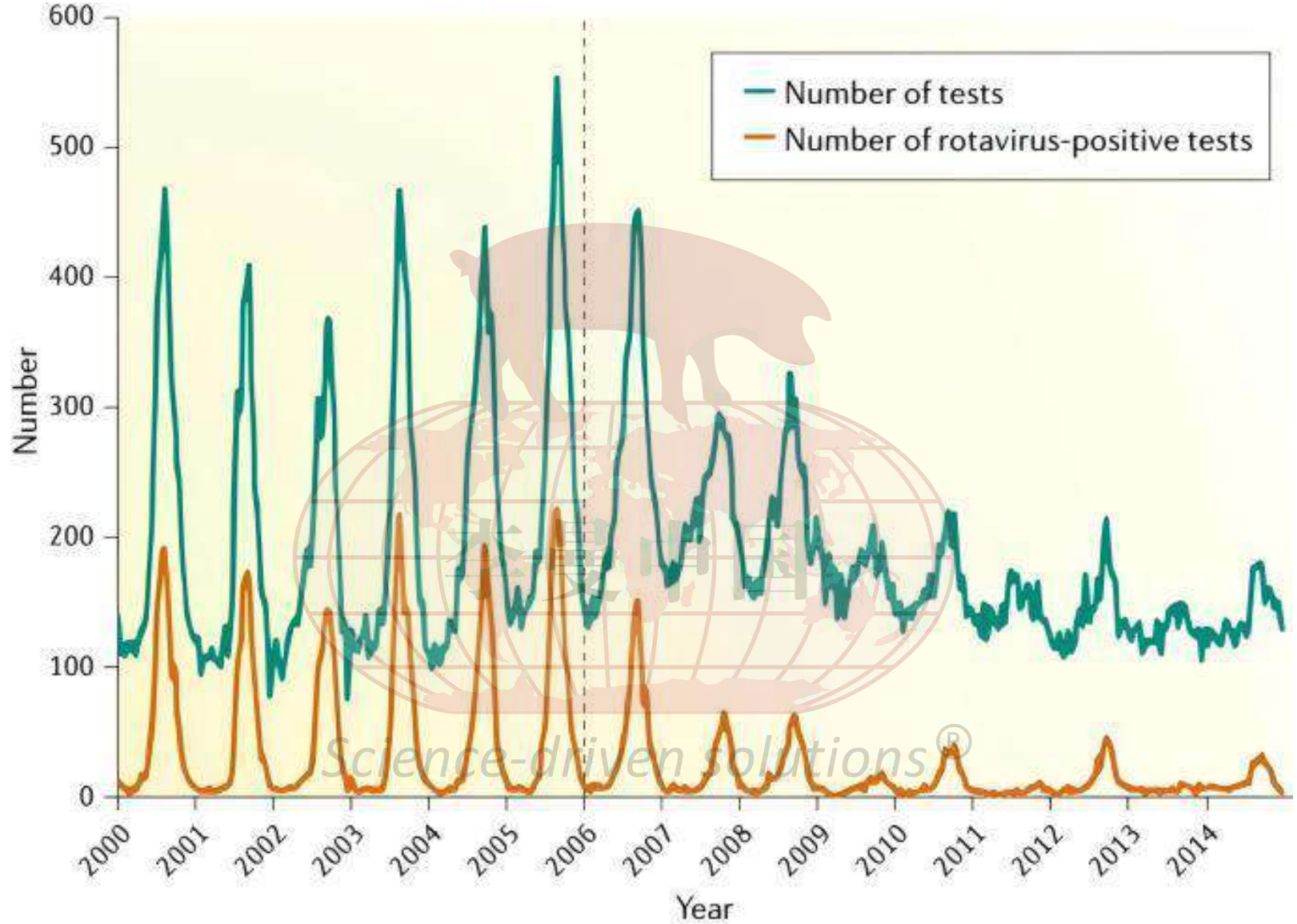


中国G5型轮状病毒疫苗的投入使用为2015年

The launch of the G5 rotavirus vaccine in China was in 2015

阳性率下降约13%

The positivity rate has decreased by about 13%



S—○ E. C◎∠／／□◎◠
○↗↗,∠Ⓛ 2017

,

R&D of PoRV vaccine PoRV疫苗的研发

- The highly genetic variation among rotaviruses hinders vaccine development programs in humans and animals;
- 轮状病毒之间的高度遗传变异阻碍了人类和动物的疫苗开发计划；

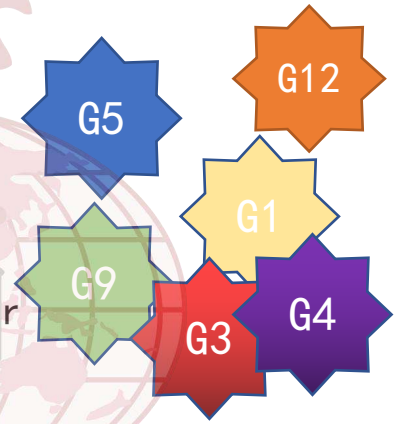
- Multivalent vaccines will be more effective than monovalent vaccines;
- 多价疫苗将比单价疫苗更有效；

- Try to development a broad spectrum antigenic strain of PoRV
- 尝试开发广谱PoRV抗原株

多价疫苗的研制
Development of multivalent vaccine

■ Multivalent live vaccine 多价活疫苗

- □ Attenuated virus by passage通过传代减毒
- □ Reverse genetic system逆向遗传系统



- 同型的毒株保护率更高
- The protection rate of homologous strains is higher

- 主要流行血清型的全覆盖
- Full coverage of major prevalent serotypes

- 口服途径免疫
- Oral route immunization

■ 多价灭活疫苗或亚单位疫苗
■ Multivalent kill vaccine or subunit vaccine

A群轮状病毒分离及不同基因型毒株间交叉中和
Isolation of Group A Rotavirus and Cross Neutralization among Different Genotyping Strains

病毒分离方法
Virus isolation method

已成功分离的病毒
Successfully isolated virus

G9P[23]、G5P[23]、G3P[23]、

G4P[23]、G1P[7]、G1P[23]、

G12P[7]、**$G_XP_{[Y]}$**

>10^8-10^9 $TCID_{50}$/ml（贴壁细胞）

血清交叉中和试验结果
Serum cross neutralization test results

病毒10^3 $TCID_{50}$/ml

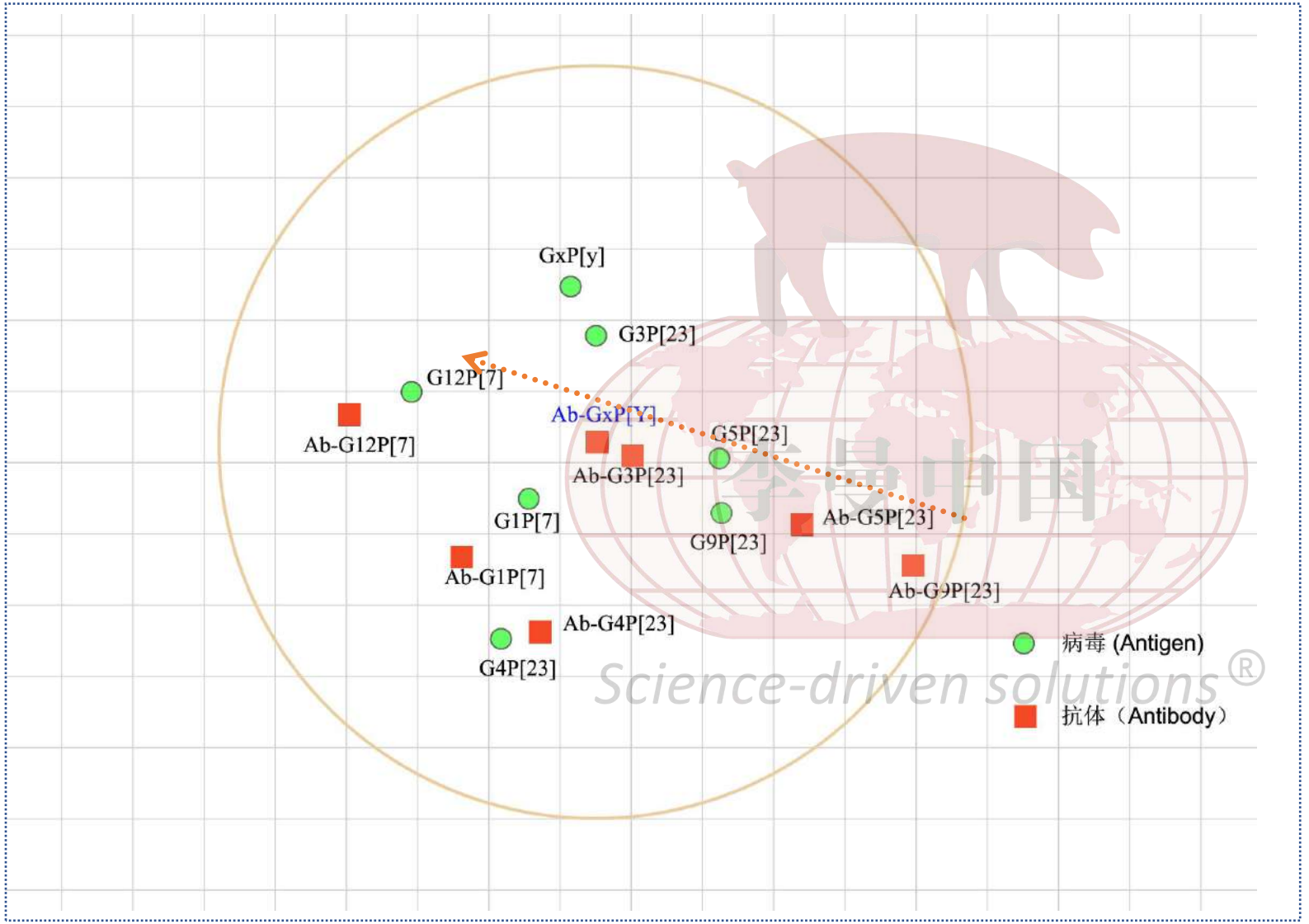
	G5P[23]	G9P[23]	G1P[7]	G12P[7]	G3P[23]	G4P[23]	G_XP[Y]
G5P[23]	12800	3200	200	200	1280	128	3200
G9P[23]	12800	51200	200	400	1280	512	6400
G1P[7]	400	800	3200	400	1600	512	6400
G12P[7]	400	400	400	6400	200	128	1600
G3P[23]	400	800	200	400	3200	64	3200
G4P[23]	400	400	800	400	400	2048	1600
G_XP[Y]	256	512	128	256	256	128	6400

不同基因型间较弱的交叉中和是多基因型并存的结果

Weak cross neutralization between different genotypes is a result of the coexistence of multiple genotypes

不同血清型PoRV抗原抗体交叉反应分析

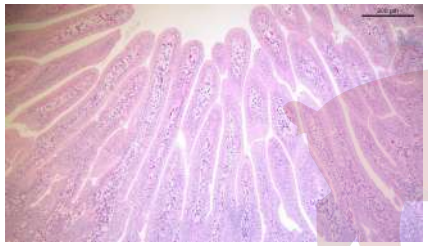
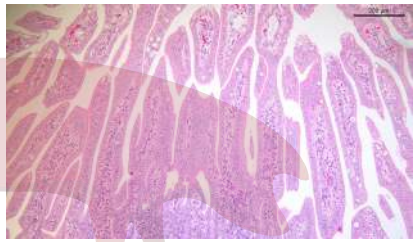
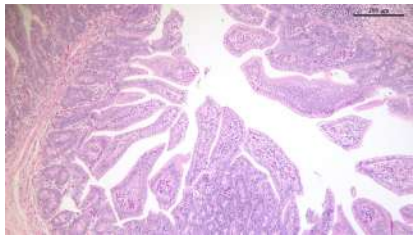
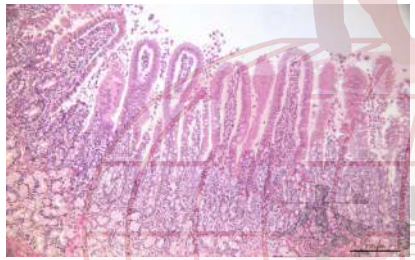
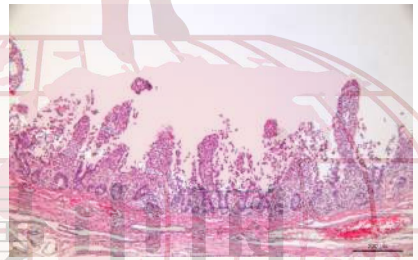
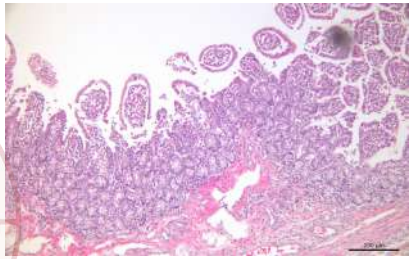
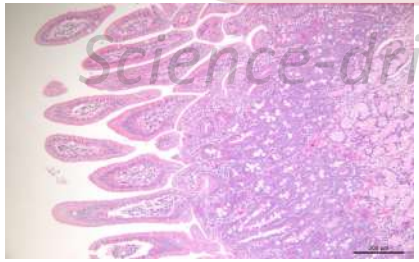
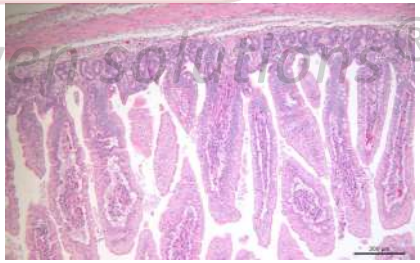
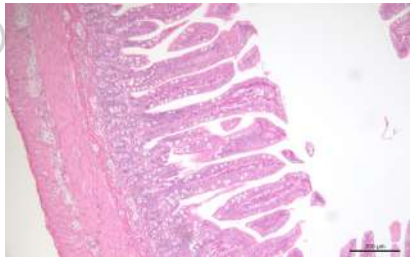
Cross reactivity analysis of different serotypes of PoRV antigen antibody



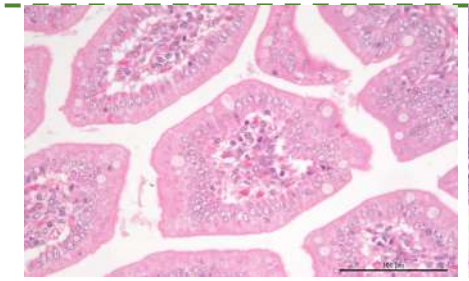
- GXP[Y]血清位于相对中心位置，说明其具有广谱交叉反应性.
- GXP [Y] serum is located at a relatively central position, indicating its broad-spectrum cross reactivity
- 主要流行基因型毒株间与其它基因型毒株间交叉较弱。
- The main prevalent genotype strains have weak crossover with other genotype strains.

广谱疫苗候选毒株的免疫保护试验及病理组织学结果

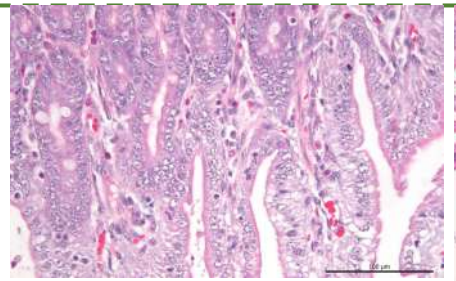
Immune protection test and histopathological results of broad-spectrum vaccine candidate strains

	十二指肠 Duodenum	空肠 Jejunum	回肠 Ileum
空白对照 Blank control			
攻毒对照 Challenge control			
	固有层 少量炎性细胞浸润 A small amount of inflammatory cell infiltration in the lamina propria	绒毛萎缩，数量减少 Villiae atrophy and reduction in quantity	绒毛萎缩，数量减少 Villiae atrophy and reduction in quantity
GX免疫+攻毒（GX）			
	无病理损伤 No pathological damage	无病理损伤 No pathological damage	无病理损伤 No pathological damage

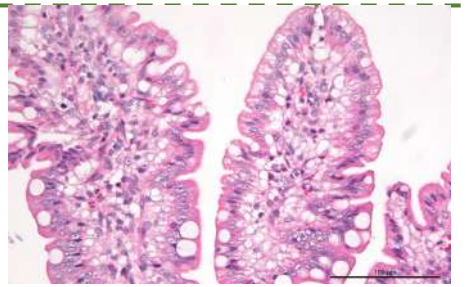
GX免疫+攻毒（G5）



少量中性粒细胞浸润
A small amount of neutrophil infiltration

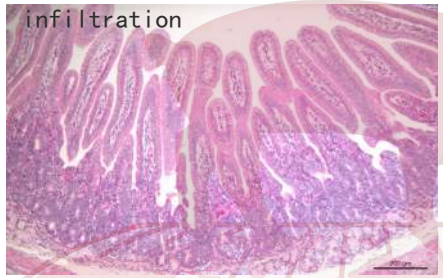


少量中性粒\嗜酸性细胞浸润
A small amount of neutrophil /eosinophil infiltration

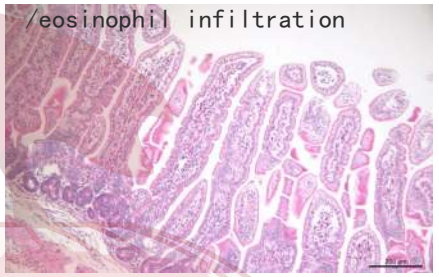


少量中性粒\嗜酸性细胞浸润
A small amount of neutrophil /eosinophil infiltration

GX免疫+攻毒（G9）



无病理损伤
No pathological damage

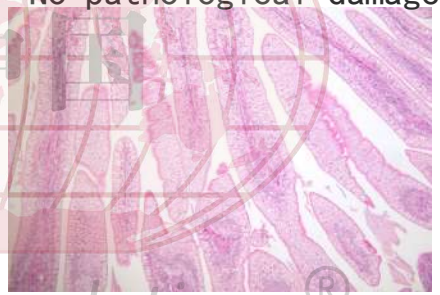


无病理损伤
No pathological damage

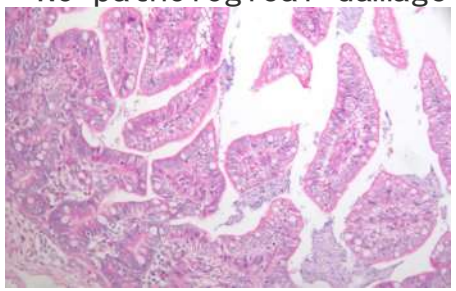
无病理损伤
No pathological damage

GX免疫+攻毒（G3）

无病理损伤
No pathological damage

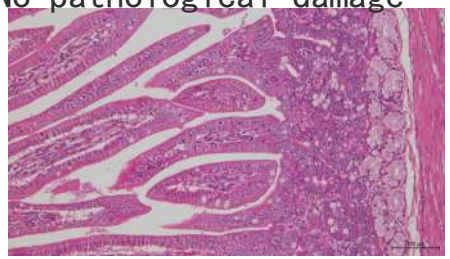


无病理损伤
No pathological damage

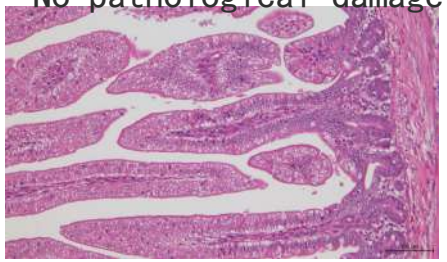


无病理损伤
No pathological damage

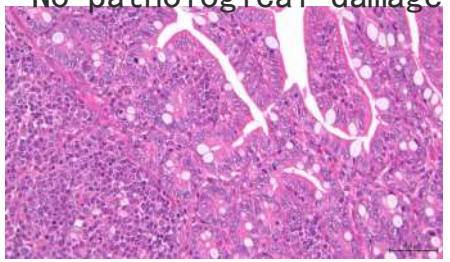
GX免疫+攻毒（G4）



无病理损伤
No pathological damage



无病理损伤
No pathological damage

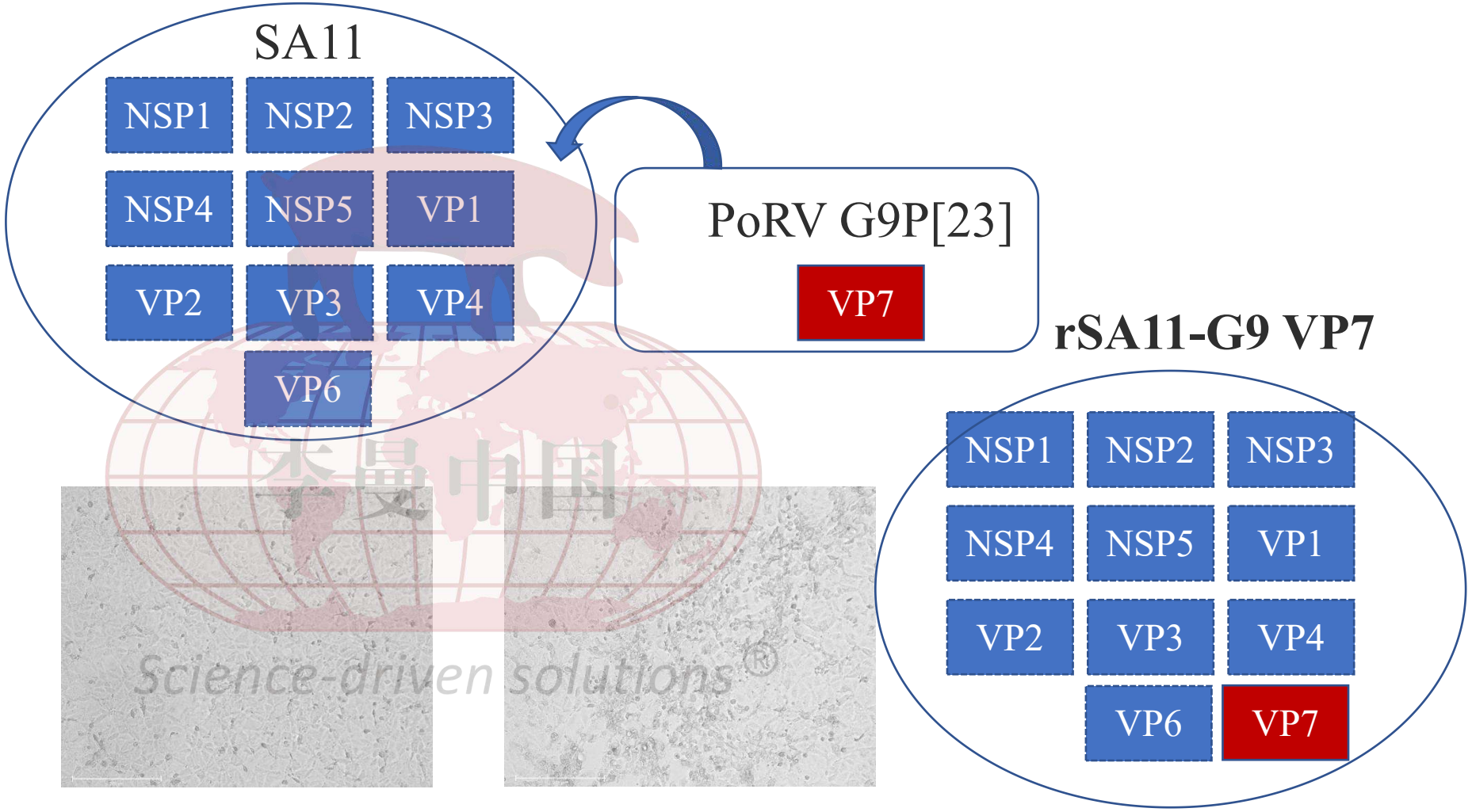


无病理损伤
No pathological damage

Virus passage and titer 病毒代次和滴度

Strain	Passage	Titer （$TCID_{50}$/ml）
G9P[23]	60	$2*10^8$
G5P[23]	60	$1*10^8$
G4P[23]	60	$2.5*10^8$
G3P[23]	55	$2*10^8$
G1P[7]	55	$3*10^8$
G12P[7]	55	$3*10^8$
G1P[23]	15	$3*10^8$

候选病毒株的反向遗传系统
Reverse genetic system for candidate virus strain



测序结果表明，VP7来自PoRV G9，其他基因属于SA11菌株。

Sequencing result showed that VP7 is from PoRV G9 and other genes beblong to strain SA11.

科学免疫策略
Scientific immunization strategy

- 做好被动免疫和主动免疫，猪群普免+母猪跟胎
- Implement passive and active immunity, including general immunization for pig herds and follow-up immunization for sows and fetuses

- 低胎次母猪加强免疫次数，尤其是初产母猪群
- Low parity sows should strengthen their immunity frequency, especially in the group of primiparous sows

- 尽可能做到明确基因型，做到同型免疫
- Try to clarify the genotype as much as possible and achieve same type immunity

轮状病毒的防控策略
Corrent strategies against PoRV

- 正确的诊断
- Correct diagnosis

- 疫苗的免疫（循环抗体）
- Immunization of vaccines (circulating antibodies)

- **对症治疗**
- **Symptomatic treatment**

- 生物安全
- Bio-Safety

对症治疗
Symptomatic treatment

- 轮状病毒发生后，对于发生腹泻的猪只，可采取饮用口服补液盐，来减少其死亡。
- After the occurrence of rotavirus, pigs with diarrhea can drink oral rehydration salts to reduce their mortality.

- 用经产母猪（4-5胎以上）母猪代养可以减少损失
- Using multiparous sows (4-5 or more) as substitutes for sows can reduce losses

轮状病毒的防控策略
Corrent strategies against PoRV

- 正确的诊断
- Correct diagnosis

- 疫苗的免疫（循环抗体）
- Immunization of vaccines (circulating antibodies)

- 对症治疗
- Symptomatic treatment

- 生物安全
- Bio-Safety

生物安全 Biosafety

- 消毒+空舍+全进全出
- Disinfection+emptying+full in and full out

- 内防扩散 外防输入
- Internal diffusion prevention and external input prevention

- 聚焦传染病的发生的三要素，猪 +人+ 物
- Focusing on the three elements of infectious disease occurrence, pigs+humans+animals

- 生物安全的系统思维和执行力
- Systematic thinking and execution of biosafety

轮状病毒的消毒与杀灭
Disinfection and killing of rotavirus

- 过氧化氢 酚类（苯酚1-2）、碘类（！%）消毒剂有效；
- Hydrogen peroxide phenol (phenol 1-2) and iodine (!%) disinfectants are effective;

- 75%酒精可用于手部消毒，洗必泰无效。
- 75% alcohol can be used for hand disinfection, but chlorhexidine is ineffective.

- 适当浓度的漂白剂可用作无缝隙、坚硬的物体表面的清洁
- Appropriate concentration of bleach can be used for cleaning seamless and hard surfaces of objects

- 强酸、强碱可杀灭轮状
- Strong acids and alkalis can kill roundworms

- 56℃ 30分钟可以灭活病毒
- 56 ℃ for 30 minutes can inactivate the virus

总结 Summary

- 我国的A群轮状病毒感染呈多血清的感染状态，其G基因型以G[9]、G[5]、G[12]为主，P基因型以P[23], P[13] and P[7]为主
- The infection of Group A rotavirus in China is characterized by a multi serum infection state, with G genotypes mainly consisting of G [9], G [5], and G [12], and P genotypes mainly consisting of P [23], P [13], and P [7]
- 在我国也存在C群轮状病毒的感染，G[6]P[5],G[1]P[5],G[9]P[X]
- There are also infections of Group C rotavirus in China, including G [6] P [5], G [1] P [5], G [9] P [X]
- 同型的轮状病毒可以诱导很好的交互免疫，异型病毒有一定的交叉保护，不同基因型之间的交叉保护能力不同。
- Homologous rotavirus can induce good mutual immunity, while heterozygous viruses have certain cross protection, and the cross protection ability between different genotypes varies.
- 轮状病毒活疫苗是包括人的轮状病毒感染在内的有效防控措施
- Rotavirus live vaccine is an effective prevention and control measure, including human rotavirus infection
- 基于反向疫苗学及经典多联口服多联疫苗和光谱疫苗是未来发展的方向。
- The future development direction is based on reverse vaccination, classic multi dose oral multi dose vaccines, and spectral vaccines.

总结 Summary

- 高水平的循环抗体是轮状病毒保护的关键，疫苗免疫和自然野毒感染是保证其高水平产生的主要策略
- High levels of circulating antibodies are key to rotavirus protection, and vaccine immunization and natural wild-type infection are the main strategies to ensure their high-level production
- 生产实践中，要最好轮状病毒引起的腹泻的鉴别诊断和基因分型，有针对性的采取防控措施。
- In production practice, it is important to differentiate and genotype diarrhea caused by rotavirus, and take targeted prevention and control measures.
- 对症治疗（补充水分和营养）可以降低其死亡率，但对集团化养猪企业操作的便捷性较差。
- Symptomatic treatment (supplementing water and nutrition) can reduce its mortality rate, but it is less convenient for group pig farming enterprises to operate.

猪场中轮状病毒发生比率增加的关键原因
The key reason for the increase in the incidence rate of rotavirus in pig farms

- 在腹泻防控中，只关注了PEDV，而忽略了轮状，
- In the prevention and control of diarrhea, only PEDV has been focused on, while rotavirus has been overlooked,
- ASF发生后，大量的后备猪补栏，由于后备猪低水平的循环抗体，导致轮状病毒的发生
- After the occurrence of ASF, a large number of gilts were restocked. Due to the low level of circulating antibodies in gilts, the occurrence of rotavirus occurred
- 集约化饲养，饲养规模增大，
- Intensive feeding, increasing the scale of feeding,
- 生猪大面积流动（运输与调动）
- Large scale flow of live pigs (transportation and mobilization)

未来生猪产业如何应对轮状病毒感染
How to deal with rotavirus infection in the future pig industry

- 重视轮状的防控，加强疫苗研发（通用+多价疫苗）
- Pay attention to the prevention and control of rotavirus and strengthen vaccine research and development (universal+multivalent vaccines)
- 加强后备猪的免疫和驯化,提高妊娠母猪的循环抗体；
- Strengthen the immunity and domestication of gilts, and enhance the circulating antibodies of pregnant sows;
- 科学有序补栏；
- Scientific and orderly filling of pens;
- 做好生物安全管理；
- Ensure effective biosafety management;
- 做好环境温度与湿度控制；
- Ensure proper control of environmental temperature and humidity;
- 做好猪群的健康管理；
- Manage the health of pig herds effectively;

敬请批评指正！
Thanks！

田 进　研究员

时洪艳　研究员

张 鑫　副研究员