African swine fever
A great threat to the Asian food security

KM Biologics Co., Ltd.
Tomoyuki Tsuda
Technical Advisor
Animal Pharmaceuticals Division
Summary

African swine fever

- One of the most devastating pig disease.
- Highly contagious and high mortality (~100%).
- No vaccines available.
- Virus can persist for a long time in the environment.

Outbreak in China

- 19 provinces /autonomous region/ municipalities.
- China is home to around half of the global pig population.
- Various production system (traditional, small-scale, large-scale)

Threat and countermeasure

- Raise the possibility of further spread to Southeast Asia and the Korean Peninsula and Japan.
- Preventing the entry of ASFV into both domestic and wild boar populations
Topics

- Global pig and pork production
- History of African swine fever
- African swine fever (virus, disease, transmission)
- Next scenarios of ASF in Asia
Global pig and pork production
Pork is the most consumed meat from terrestrial animals, accounting for over 37 percent of global meat intake, followed closely by chicken (35.2%) and beef (21.6%) 

(FAO, 2013)
Global pig production

Number of pigs (x 1 000 000) in the world by region (1961-2014)

Source: FAOSTAT, 2016
Global distribution of pigs

Head per km$^2$

- < 1
- 1 - 5
- 5 - 10
- 10 - 20
- 20 - 50
- 50 - 100
- 100 - 250
- > 250

Islamic countries assumed to have insignificant numbers of pigs

Global pig production

China 474,110 (48%)
USA 67,730 (7%)
Brazil 37,930 (4%)
Germany 28,340 (3%)
Vietnam 26,760 (3%)
Others 351,780 (35%)

Total 987 million in the world,
about half of world’s pig population is raised in China.

Number of pigs (x 1,000) in 2014.
Global pork production (x 1,000 tons) by carcass weight in 2014

- China: 52,730 tons (47%)
- USA: 10,510 tons (9%)
- Germany: 5,490 tons (5%)
- Spain: 3,430 tons (3%)
- Brazil: 3,280 tons (3%)
- Other: 37,590 tons (33%)

Total: 113 million tons in the world
Chinese consumption of pork and its products per capita is highest in the world.

**Source:** FAOSTAT
Fresh meat and other pork products imported into China (x 1,000 tons)
History of African swine fever
History of ASF (~2007)

- **Portugal**: 1957, 60-99
- **Spain**: 1960-1995, 92 mln USD
- **France**: 1964, 1967, 1977, Genotype 1
- **Italy**: 1967, 69, 80, 93
- **Russia**: 1977
- **Belgium**: 1985
- **Malta**: 1978
- **Netherlands**: 1986, Genotype 1
- **Caucasus And Russia**: 2007-present, Genotype 2
- **Sardinia**: 1982-present, Genotype 1
- **Angola**: 1957
- **Kenya**: 1921 (First described)
- **Dominican Republic**: 1978, 1981
- **Haiti**: 1979, 1984
- **Cuba**: 1971, 1980
- **Brazil**: 1978, 1981
- **France**: 1964, 1967, 1977, Genotype 1
- **Spain**: 1960-1995, 92 mln USD
“New era” of ASF (Georgia 2007 ~)

First clinical signs – 22nd of April
Diagnosis of ASF – 3rd of June

ASFV
Genotype II

Russia

Georgia

Armenia

Azerbaijan
Outbreaks of ASF in Eurasia (2007~)

- **Azerbaijan** 2008.1
- **Ukraine** 2012.7
- **Bulgaria** 2018.8
- **Moldova** 2016.10
- **Rumania** 2017.7
- **Hungary** 2018.4
- **Poland** 2014.2
- **Belgium** 2018.9
- **Czech** 2017.6
- **Belarus** 2013.6
- **Lithuania** 2014.1
- **Latvia** 2014.6
- **Estonia** 2014.9
- **Russia** 2007.11
- **Georgia** 2007.4
- **Armenia** 2007.8
- **Irkutsk** 2017.3~
- **2017.7~**
- **2018.8~**

Expected routes of ASFV infection

MAFF Japan, 3rd Oct 2018
Outbreaks of ASF in Europe and Russia

- **Belgium**: 2018.9.9, W 26
- **Czech**: 2017.6.27, W 220
- **Hungary**: 2018.4.20, W 35
- **Poland**: 2014.2.13, P 213, W 2705
- **Latvia**: 2014.6, P&W 2769
- **Lithuania**: 2014.1.24, P&W 1791
- **Estonia**: 2014.9, P&W 3106
- **Russia**: 2007, P&W 1113
- **Belarus**: 2013.6.19, P 2
- **Ukraine**: 2012.7.30, P 333, W 84
- **Moldova**: 2016.9.17, P 29, W 7
- **Bulgaria**: 2017.7.27, P 957, W 52
- **Bulgaria**: 2018.8.31, P 1

**Number of outbreaks since 2007 until 11th Oct, 2018**
Outbreaks of ASF in China

ASF has been detected in a total of 78 villages/sites in 15 provinces, 1 autonomous region and 3 municipalities.

Nov. 19th 2018
Global distribution of pigs

Density: low  high
African swine fever
African swine fever (ASF)

ASF is a contagious viral disease of pigs and shows haemorrhagic fever. Clinical signs are ranging from peracute, acute, subacute, to chronic and subclinical symptoms.

In the acute form, lethality reach to 100 percent.

ASF is a severe threat to pig production systems. (food security, livelihoods of pig producers, other actors in the supply chain, international trade)

Domestic pigs and wild boar are susceptible to ASF.

African wild suids do not show clinical signs of infection, they are, together with Ornithodoros soft ticks, the natural hosts and reservoir of the virus.
African swine fever virus (ASFV)

ASFV is a double-stranded DNA virus, member of the Asfarviridae family and the only DNA virus transmitted by arthropods, soft ticks of the *Ornithodoros* genus.

ASFV is a large, enveloped virus and an average diameter of 200 nm.

The viral genomes vary in length between 170 and 190 Kbp and encode between 151 and 167 open reading frames.

The ASFV particle has an icosahedral morphology composed by the internal core formed by the central genome, matrix shell, inner membrane surrounding the core, the capsid, outermost layer of the intracellular virions.

The extracellular virion possess an additional external envelope that is obtained when the virus buds out through the plasma membrane. However, the importance of this envelope is unclear as it is not required for infectivity.
African swine fever virus

The global genotypic diversity of ASFV

Source: INIA-CISA, 2016
Clinical finding of ASF

Differeed by
Virus
\[ \text{Peracute: High fever (>41°C), loss of appetite, inactivity, sudden death 1-3 days before the development of any clinical sign} \]
\[ \text{Acute: High fever, loss of appetite, sleepy and weak, death (6~9 days), bluish-purple areas and haemorrhages (spot-like or extended) on the ears, abdomen, and/or hind legs} \]
\[ \text{Subacute: die within 7-20 days, Clinical signs are similar (although generally less intense) to those observed in the acute form, Fluctuating fever, accompanied by depression and loss of appetite,} \]
\[ \text{Chronic : Naturally attenuated strain, Clinical signs begin 14 to 21 days post-infection with slight fever} \]
\[ \text{Unapparent: Warthog/Phacochoerus africanus (natural hosts)} \]

\[ \begin{array}{lll}
\text{Mortality} & \text{Virulence} & \text{Routs} \\
90~100\% & \text{High} & \leftrightarrow \\
\text{~60\%} & \text{Medium} & \leftrightarrow \\
2~10\% & \text{Low} & \\
\end{array} \]
Clinical sign of ASF

A. Pigs are visibly weak with fever and huddle to stay warm.
B-E. Bloody diarrhoea and distinct hyperaemic (red) areas on skin of neck, chest and extremities.
F. Cyanosis (bluing) at the tips of ears.
G-I. Necrotic lesions on skin of the abdomen, neck and ears.
Rout of infection

Pig and wild boar are infected with virus by
Oro-nasal route: contaminated feed, table scrap, kitchen waste, contaminated pork meat and pork products, scavenging carcasses

Direct contact: affected pig (saliva, tears, nasal secretions, urine, faeces, secretions from the genital tract and blood)

Indirect contact: pig-derived products (swill, fomites, bedding) can be transported over long distances by vehicles and people

Arthropod borne: Ornithodoros ticks
Transmission of ASFV

The ASF virus persists in distinct cycles – traditionally, the sylvatic cycle (1), the tick-pig cycle (2) and the domestic (pig-pig) cycle (3). More recently, a wild boar cycle (4) has been described.
Transmission of ASFV

1. **SYLVATIC CYCLE**  (Southern and Eastern Africa)

ASFV is maintained by tick-to-warthog (natural hosts) transmission. Warthogs are infected by Ornithodoros moubata bites in the first 6-8 weeks of life, and subsequently develop sufficient viraemia (2-3 weeks) to infect other ticks. The young warthogs recover showing no clinical signs. In endemic areas, up to 100 percent of warthogs may have antibodies to ASFV.

2. **TICK-PIG-CYCLE**  (Iberian Peninsula)

Ornithodoros erraticus, local ticks living in pig shelters, maintains ASFV and transfer to pigs.

3. **DOMESTIC CYCLE**  (The most commonly reported scenario)

The virus is maintained in pigs in the absence of wild suids and ticks. The virus may spread through direct contact with infected pigs, ingestion of pork or other contaminated products, or indirectly through fomites.

4. **WILD BOAR CYCLE**  (Eastern Europe, the Caucasus and Sardinia)

Wild boar populations play an important role in the maintenance of viral circulation and infection. Particularly where there are free-ranging or scavenging populations of pigs in the area.
<table>
<thead>
<tr>
<th>Ornithodoros species</th>
<th>Geographical distribution</th>
<th>Trans-ovarial</th>
<th>Trans-stadial</th>
<th>To pigs</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>O. Erraticus (O. marocanus)</td>
<td>Iberian Peninsula and Northern Africa</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Inhabits pigsties and maintains a cycle in domestic pigs</td>
</tr>
<tr>
<td>O. Moubata complex</td>
<td>Southern and Eastern Africa, Madagascar, one record from Sierra Leone (warthog burrow)</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Depending on the subspecies, it may inhabit warthog burrows and maintain the sylvatic cycle in warthogs, but can also inhabit pigsties (maintaining a cycle in domestic pigs)</td>
</tr>
<tr>
<td>O. puertoricensis</td>
<td>Caribbean</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Proved an efficient vector, but no virus detected despite large numbers collected in Haiti and Dominican Republic after ASF outbreaks</td>
</tr>
<tr>
<td>O. coriaceus</td>
<td>USA</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Proved an efficient vector experimentally</td>
</tr>
<tr>
<td>O. turicata</td>
<td>USA</td>
<td>?</td>
<td>?</td>
<td>Yes</td>
<td>Proved able to transmit the virus to pigs experimentally</td>
</tr>
<tr>
<td>O. savignyi</td>
<td>Africa</td>
<td>?</td>
<td>?</td>
<td>Yes</td>
<td>Is a desert tick not associated with pigs or warthogs</td>
</tr>
<tr>
<td>O. sonrai</td>
<td>Sahel in North Africa (southward extension of range to south Senegal)</td>
<td></td>
<td></td>
<td></td>
<td>ASF viral genome detected by PCR in four out of 36 ticks on farms where outbreaks occurred in 2004 and 2005</td>
</tr>
</tbody>
</table>

(Source: University of Pretoria)
## Survival time of ASFV in environmental conditions

<table>
<thead>
<tr>
<th>Item</th>
<th>ASFV survival time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meat with and without bone and ground meat</td>
<td>105 days</td>
</tr>
<tr>
<td>Salted meat</td>
<td>182 days</td>
</tr>
<tr>
<td>Cooked meat (minimum of 30 minutes at 70 °C)</td>
<td>0</td>
</tr>
<tr>
<td>Dried meat</td>
<td>300 days</td>
</tr>
<tr>
<td>Smoked and deboned meat</td>
<td>30 days</td>
</tr>
<tr>
<td>Frozen meat</td>
<td>1 000 days</td>
</tr>
<tr>
<td>Chilled meat</td>
<td>110 days</td>
</tr>
<tr>
<td>Offal</td>
<td>105 days</td>
</tr>
<tr>
<td>Skin/Fat (even dried)</td>
<td>300 days</td>
</tr>
<tr>
<td>Blood stored at 4 °C</td>
<td>18 months</td>
</tr>
<tr>
<td>Faeces at room temperature</td>
<td>11 days</td>
</tr>
<tr>
<td>Putrefied blood</td>
<td>15 weeks</td>
</tr>
<tr>
<td>Contaminated pig pens</td>
<td>1 month</td>
</tr>
</tbody>
</table>
Development of ASFV Vaccines

1. Inactivated Candidate Vaccines
   Unsuccessful
2. Subunit Vaccine Approaches

<table>
<thead>
<tr>
<th>Genes/Proteins Delivered</th>
<th>Type of Vaccine</th>
<th>Challenge</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>p54/E183L, p30/CP204L</td>
<td>Baculovirus expressed proteins</td>
<td>Partial protection</td>
<td>[98]</td>
</tr>
<tr>
<td>P54/E183L, p30/CP204L, p72/B646L CD2v/pEP402R</td>
<td>Baculovirus expressed proteins</td>
<td>No protection</td>
<td>[100]</td>
</tr>
<tr>
<td>p54/E183L, p30/CP204L</td>
<td>Baculovirus expressed proteins</td>
<td>Partial protection</td>
<td>[62]</td>
</tr>
<tr>
<td>Ubiquitin-CD2v/pEP402R- p54/E183L-p30/CP204L DNA expression library</td>
<td>DNA vaccination</td>
<td>No protection</td>
<td>[107,117]</td>
</tr>
<tr>
<td>DNA expression library</td>
<td>DNA vaccination</td>
<td>Partial protection</td>
<td>[117]</td>
</tr>
</tbody>
</table>

Further work will be needed in order to identify both the antigens to be included in a potential subunit vaccine and the optimal immune mechanisms to be triggered after vaccination in order to confer solid protection against ASFV.

Gaps and Future Directions

Solid protection, Safety, genetic stability, virulence genes to be deleted, licensed cell line for vaccine production.

Disinfection of ASFV

Heat: >70°C for 30min., 80°C for 3min.
pH : <pH3.9、>pH11.5
Disinfectants:

8/1000 sodium hydroxide (30 minutes)
hypochlorites – 2.3% chlorine (30 minutes)
3/1000 formalin (30 minutes)
3% ortho-phenylphenol (30 minutes)
iodine compounds
Effective commercial products are also available.
Next scenarios of ASF in Asia
Next scenarios of ASF

Spread only in domestic pig herd.
   affected pigs and farms will be increased in limited areas (only in farm).
   (Controllable)

Invade into wild boar population
   Spread in the wild boar population though scavenging carcasses.
   (Unable to control and become enzootic infection)

Transferred by local ticks
   Persistent in environment.
   (Become enzootic disease)

Countermeasures

Preventing the ASFV invasion both domestic pig and wild boar populations, and eradicating the disease as soon as it is detected, should be implemented for minimizing its impact.
Thank you for your attention