Global Conference on Rabies Control
Towards Sustainable Prevention at the Source
Incheon (Republic of Korea)
7-9 September 2011

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Rabies has been a known killer disease of humans and animals since the beginning of recorded history and unfortunately remains so to this day, causing the entirely preventable death of thousands of people annually, especially in countries in Asia and Africa where insufficient means are available to create an effective immune buffer and protective barrier between the animal source of the disease and potential human victims.

After hosting two successful international conferences on rabies in 2005 (Kiev, Ukraine) and in 2007 (Paris, France) in collaboration with WHO and EC, the OIE, along with its main partners WHO, FAO and EC, recognises the need to convene a global conference focused on rabies control at the animal source. The past two OIE international conferences on rabies focused on the epidemiological evolution of rabies in Eurasia, the technology available to control and ultimately eliminate rabies in domestic animals as well as in wildlife, the importance of inter-sectorial collaboration and the modern tools to diagnose and prevent human rabies cases after exposure. Despite considerable advances in novel technologies for the control of rabies and the technical and institutional know-how collected in successful rabies control programmes, rabies remains a highly significant and fully preventable cause of death in humans who are exposed to rabid animals. Thanks to the major efforts of the research community over the past years, including the OIE Reference Laboratories and the private sector, the veterinary and public health services have now a robust set of tools to control rabies at its animal source. Nevertheless, many governments neglect or are still reluctant to seriously tackle rabies control at the animal source for a number of reasons including the lack of economic incentive to fund programmes to control rabies in dogs compared with other disease control programmes in livestock and the fact that veterinary services’ governance is not adapted to designing appropriate programmes in many countries. This third, global conference emphasises on the responsibility of veterinary services and the institutional changes needed to sustainably control rabies at the animal source. For millennia, dogs have been the main source of human infection, and the veterinary profession has been called upon to apply its knowledge and skills in zoonosis control at the animal source to protect humans. When it comes to rabies control programmes however, neither public health nor veterinary services should act in isolation. For several years, the OIE and its donors have supported interested countries around the globe to improve the governance and delivery of their veterinary services. Good veterinary governance is crucial to applying successfully the technologies and tools available for rabies control. But most important, veterinary services have to actively advocate for and establish collaboration across different sectors, beyond public health services.

This conference provides a platform to encourage exchanges of experiences on rabies control at the animal source. It seeks for renewed concepts of inter-sectorial collaboration or to identify key elements for the sustainable implementation of existing concepts to tackle rabies at the animal source. It sheds light on the cost–benefit aspects of rabies control and promotes international solidarity through discussion between countries and regions, between national Chief Veterinary Officers (OIE Delegates), researchers, regulatory experts, representatives from NGOs and the human health community with the ultimate goal of controlling rabies world-wide.

On behalf of the OIE Members I would like to thank our major partners who contributed technically and financially to this conference, namely the FAO, the WHO, the EC, the Australian Government, the Government of Germany, the Government of the USA, the Government of the Republic of Korea and a number of other sponsors who kindly accepted to host and support this conference.

Dr Bernard Vallat
OIE Director General
ORGANISATION OF THE CONFERENCE

1. Steering Committee:
   Dr Daniel Chaisemartin
   Dr Gab Soo Jeong
   Dr Juan Lubroth
   Dr Kazuaki Miyagishima
   Dr Lorenzo Savioli

2. Scientific Committee
   Dr Deborah Briggs
   Dr Gideon Brückner
   Dr Katinka De Balogh
   Prof. Anthony Fooks
   Dr Lea Knopf
   Dr François Meslin
   Dr Thomas Müller
   Dr Charles Rupprecht
   Dr Jae Young Song
   Dr Noël Tordo

3. Organising Committee
   Dr Ronello Abila
   Dr Daniel Chaisemartin
   Dr Tomoko Ishibashi
   Dr Yong Joo Kim
   Dr Gardner Murray
   Dr Cheon Seob Roh
The abstract, in English only, for each presentation and for each poster is included in this abstract book.

Following the conference, the abstracts, PowerPoint presentations and the final recommendations will be made available on the OIE website.

The OIE also intends to publish a booklet with full papers of the presentations of the conference. Hard copies of this publication will be distributed to all the participants of the conference including the OIE Delegates and will be available for purchase from the OIE publications department.

The conference is held in Songdo Ramada Hotel, Incheon, Republic of Korea, from 7 to 9 September 2011.

Songdo Ramada Hotel
812 Dong Chun1Dong
Yeonsugu, Incheon
Republic of Korea

Tel: + 82 (0)32 832 2000
Fax: + 82 (0)32 830 2349

http://www.ramada-songdo.co.kr/eng/index.asp

Speakers will give their presentations in one of the official OIE languages (English, French or Spanish) with simultaneous translation into the other two.
PROGRAMME

Tuesday 6 September 2011
17:00 – 19:00  Registration

Day 1 : Wednesday 7 September 2011
08:00 – 09:00  Registration (continued)

OPENING ADDRESSES

Chair: Delegate of Korea

09:00 – 09:40  Welcome by the Representative of Korean Government

Welcome by the FAO Representative

Welcome by the WHO Representative

Welcome by the EC Representative

Welcome by the Director General of the OIE

SESSION 1:

THE REALITY OF RABIES : SETTING THE SCENE

Chair: Dr Katinka De Balogh

09:40 – 10:10  Global perspective of rabies  

Dr Alexander Wandeler

10:10 – 10:25  Case Report (1) – India  

Dr Abdul Rahman

10:25 – 10:40  Case Report (2) – China  

Prof. Changchun Tu

10:40 – 11:00  Coffee break

SESSION 1:

THE REALITY OF RABIES : SETTING THE SCENE (CONTD)

Chair: Dr François Meslin

11:00 – 11:15  Case Report (3) – Europe (focus on wildlife)  

Dr Thomas Müller

11:15 – 11:30  Case Report (4) – America  

Dr Hugo Tamayo

11:30 – 11:45  Case Report (5) – North Africa  

Dr Mehdi El-Harrak

11:45 – 12:00  Case Report (6) – Southern and Eastern Africa  

Prof. Louis Nel

12:00 – 12:15  Case Report (7) – Republic of Korea  

Dr Dong-Kun Yang

12:15 – 12:30  Discussion

12:30 – 13:40  Lunch
SESSION 2: SCIENTIFIC ADVANCES : CURRENT AND FUTURE TOOLS AVAILABLE FOR RABIES CONTROL

13:40 – 14:00 New diagnostic tools for rabies in animals Prof. Anthony Fooks
14:00 – 14:20 New developments in rabies vaccines Dr Noël Tordo
14:20 – 14:40 Criteria for the use of parenteral and oral immunization of dogs Dr Caroline Schumacher
14:40 – 15:00 Immuno-contraception as a tool for rabies and dog population control Dr Charles Rupprecht
15:00 – 15:20 Discussion
15:20 – 15:40 Coffee break 🍵

SESSION 3: ECONOMIC DIMENSIONS OF RABIES CONTROL

15:40 – 16:00 Reassessment of the socio-economic global burden of rabies: Human and animal cost of global rabies Dr Katie Hampson
16:00 – 16:20 Impact of animal rabies on local economy Part I : on livestock and working animals Dr Katinka De Balogh
16:20 – 16:40 Impact of animal rabies on local economy Part II : on tourism, recreation and wildlife conservation Prof. Sarah Cleaveland
16:40 – 17:00 Cost of national rabies eradication programmes Dr Hans-Joachim Bätza
17:00 – 17:20 Discussion
18:00 OIE Cocktail

Day 2 : Thursday 8 September 2011

SESSION 4: INTERNATIONAL STANDARDS AND REGULATORY FRAMEWORK

09:00 – 09:20 OIE standards and scientific activities for rabies control Dr Lea Knopf
09:20 – 09:40 WHO standards for rabies control (prevention of human infection, professional hazards) Dr Thiravat Hemachudha
09:40 – 10:00 Other relevant international standards Dr William Karesh
10:00 – 10:20 International movement of pets: Individual identification, pet passports, traceability, quarantine and sanitary controls Dr Hélène Klein
10:20 – 10:40 Monitoring and control of dog populations Prof. Hassan Abdel Aidaros
10:40 – 11:00 Discussion
11:00 – 11:20 Coffee break 🍵
**SESSION 5:**

**ROLE OF VARIOUS STAKEHOLDERS IN RABIES CONTROL IN THE ANIMAL RESERVOIR**

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<td>Dr Richard Suu-Ire</td>
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<td>Local governments, municipalities and dog rabies control</td>
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19.00  Dinner
Day 3 : Friday 9 September 2011

SESSION 7:

PROGRAMME Chair: Dr Christine Fehlner-Gardiner

STRATEGIES TODAY AND TOMORROW AT THE ANIMAL SOURCE

09:00 – 09:20 Cost-benefit analysis of rabies control Prof. Jakob Zinsstag

09:20 – 09:50 Mainstreaming rabies prevention and control at national level: Focus on the role of the national Veterinary Services Dr Gideon Brückner

09:50 – 10:20 OIE activities to support sustainable rabies control: PVS, vaccine banks and the OIE twinning Dr Gardner Murray

10:20 – 10:40 Discussion

10:40 – 11:00 Coffee break

SESSION 8:

Chair: Dr Bernard Vallat

MOVING TOWARDS SUSTAINABLE PREVENTION AT THE ANIMAL SOURCE: RECOMMENDATIONS

11:00 – 11:40 General discussion

11:40 – 12:30 Presentation and adoption of recommendations

Closure of the conference

12:30 Lunch
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GLOBAL PERSPECTIVE OF RABIES

Wandeler A.I.
Canadian Food Inspection Agency (CFIA) Scientist Emeritus, Canada

Different variants of rabies viruses and/or rabies-related Lyssaviruses occur on all continents, except Antarctica. Each variant is generally associated with a principal host species whose use of space and social interactions allow the virus to persist in its populations. These principal hosts are all members of the orders chiroptera (bats) or carnivora. They all transmit the disease to other species, which are sometimes highly susceptible, but whose population biology is not conducive to maintaining an epizootic. One can distinguish between areas of the world in which dogs are the principal hosts and those where rabies is maintained in wild animals and in which only 0.1–5.0% of the rabies cases reported are in dogs. In large parts of Asia, Africa and Latin America, rabies in dogs is much more common, making up 95% or more of all diagnosed cases. Rabid dogs are the major source of human infection. The elimination of dog rabies through vaccinations and by promoting responsible dog ownership is therefore a recommendable goal for human and animal health authorities.
Rabies is endemic throughout the country except for the islands of Andaman, Nicobar and Lakshadweep. Data on animal rabies is very scarce and there is no organized system of surveillance to assess the disease burden annually. Molecular epidemiological studies on Indian isolates need to be undertaken.

The dog (97%) is the principal vector followed by cats (2 %) and others such as cattle, sheep, goats, horses, pigs, camels and monkeys. The pet dog population is about 28 million and an equal number are estimated to be stray.

The role, approaches to and effectiveness of Rabies control are not well defined. Though it is the mandate of the Government Veterinary Services it is often animal welfare organizations supported by Animal Welfare Board of India, through the municipal corporations, which are involved in vaccination of dogs as a part of catch neutering release programmes. In some cities dog population has been stabilised by neutering of dogs and vaccination coverage done which has resulted in control of both canine and human rabies. The main obstacle in preventing canine and human rabies in India is the lack of sustainable centralized effort and the fact that rabies by law is not a notifiable disease.

The affliction of domestic animals of economic importance by rabies in rural areas is an important public health concern. People in rural areas are largely ignorant of the disease. The myths and traditional practices further compound this problem. The curriculum in the medical, veterinary and other health sciences colleges does not emphasise the importance of this deadly disease.

An effective and economical tool to combat rabies would be the oral immunization of stray dogs as a complementary to parenteral immunisation. Newer oral vaccines to suit Indian conditions have been developed and are in the process of being tried. Community empowerment projects for rabies control have been highly successful.
Tu C.
Changchun Veterinary Research Institute, Chinese Academy of Agricultural Sciences, Changchun 130122, China

China has been the country reporting the second largest number of human rabies deaths worldwide since the late 1990s. The disease is predominantly distributed in south China with more than 85% of human rabies cases from rural areas. The latest epidemic wave of human rabies started in 1997 with 222 cases, reaching its peak in 2007 with 3303 cases. Currently 23 of the 31 provinces, autonomous regions and municipalities have reported human rabies cases. With the implementation of comprehensive control measures around 2005, reported human rabies cases have been significantly declining, with 2378 cases in 2008, 2108 in 2009, and 1927 in 2010.

Since the wide prevalence of dog rabies caused by very low vaccination coverage, the dog plays a pivotal role in rabies transmission in China with more than 95% of human cases ascribed to dog bites. Dog management and mass vaccination in rural area are main challenges in combating rabies in China. In contrast to urban areas, where a well-established dog registration and vaccination programme is in place, ensuring adequate immunization coverage of urban dogs, dogs in rural areas do not require registration and their vaccination is not widely accepted due to poor awareness and the high cost of vaccine administration. Therefore the immunization coverage in rural areas is commonly low and highly dependent on the economic status of the local government.

Phylogenetic analyses showed that rabies viruses isolated in China have a close relationship with those from Southeast Asia and are divided into 3 major groups. Current control measures consist of compulsory registration and vaccination of companion dogs in urban districts, gradual implementation of mass vaccination of rural dogs, increased post-exposure treatment of dog-injured people, particularly in rural areas, awareness education, and improvement of medical and veterinary infrastructures.
The current rabies situation in Europe is probably unprecedented in history. Large parts of Western, Northern and Central Europe are officially recognized as free from terrestrial rabies. This achievement is the result of stepwise intensive efforts to control and eliminate both urban (canine) and sylvatic (wildlife-mediated) rabies. Although canine rabies was yet successfully controlled using strict implementation of hygienic measures in several European countries at the beginning of the 20th century, Europe-wide elimination was accomplished by registration and mass vaccination of dogs in the 1970s.

In contrast, the emergence of fox rabies in the 1940s as a result of a transition from urban to sylvatic rabies posed a new challenge and required fundamental changes in rabies control policies. Early attempts to control fox rabies aiming at a drastic decimation of the fox population to interrupt the infectious cycle failed and were suggested as counterproductive. The increasing rabies incidence required alternative rabies control methods. In 1970s, the concept of oral rabies vaccination (ORV) offered a new perspective for rabies control in wildlife. However, appropriate tools yet had to be developed from scratch. Pioneering developments including efficacious and safe oral rabies virus vaccines, adequate vaccination strategies, machine-made baits, and automated aerial bait distribution were technical milestones on the road to success. Since 1989 the EU has become the driving force for fox rabies control in Europe via its co-financing policy of costs for disease eradication. Despite the tremendous success achieved, European countries had to face several setbacks resulting in delay in rabies elimination at a regional level. Reasons for setbacks were multifaceted and lessons had repeatedly to be learnt. In western Europe, currently all measures are directed towards the maintenance of a rabies free status by avoiding reintroduction of the disease including implementation of the pet travel scheme, risk-based surveillance and establishment of cordons sanitaire along borders to rabies endemic regions. Since complete elimination of rabies from Europe has not been achieved yet, the EU has spent more than 75 Mio € to support rabies elimination in the Turkey, Western Balkan region, Kaliningrad and north-eastern neighbouring third countries.

REFERENCES

CASE REPORT (4) – AMERICA
ELIMINATION OF HUMAN RABIES TRANSMITTED BY DOGS IN
THE LATIN AMERICA AND THE CARIBBEANS: ACHIEVEMENTS

Tamayo H.¹, Cosivi O.², Vigilato M.², Valderrama W²
(1) Advisor STP, Foot and Mouth Disease Pan American Center, Veterinary Public Health, Pan American Health Organization/World Health Organization. Rio de Janeiro, Brazil
(2) Director, Foot and Mouth Disease Pan American Center, Veterinary Public Health, Pan American Health Organization/World Health Organization. Rio de Janeiro, Brazil

In the governing bodies mandates framework from PAHO/WHO, the Inter-American Meeting at Ministerial Level on Health and Agriculture (RIMSA) and the Meeting of Directors of National Programs for Rabies Control in Latin America (REDIPRA), is inscribed the Elimination Program of Human Rabies transmitted by dog in Latin America and Caribbean.

By the year 2010 has been achieved 95% cases reduction in humans and canines. Approximately 350 human cases and 3000 canine in the early 1980s have been reduced by 2010 to less than 10 and 100 cases, respectively. The disease is focused on a few countries, and the promotion of the declaration and countries and territories international recognition of free of rabies, variants 1 and 2, according to the OIE Sanitary Code for the Terrestrial Animals.

The program success is due to the epidemiological surveillance system supported by a network of more than 100 diagnostic laboratories, ease of access and free medical treatment to more than 1,000,000 people attacked by dogs each year, the high coverage and systematic immunization of more than 45’000,000 dogs annually, as well as the information training dissemination and community participation.

Despite that from 2004-2010, the number of human rabies cases, transmitted by bats mainly by hematophagous bats, is greater than those cases of human rabies transmitted by dogs. Promote measures of surveillance and research applied to the control of the disease, particularly in the Amazon region of South America.
Rabies should be considered as a very serious public health concern with high economical consequences in North Africa; each year, around 100 human and few thousands of animal rabies cases are reported. The burden of rabies falls mostly on poor rural communities and children in particular. The dog remains the most important vector and reservoir of the disease and is responsible for almost all the reported human cases.

The declared rabies figures are rather underestimates in North Africa. Lack of laboratory diagnosis facilities and logistics to transfer suspect samples, in addition to the lack of local population involvement are responsible of the disease underreporting.

Several eradication programs have been conducted in different countries but they have only limited success in the control of rabies in urban areas without eliminating the disease. Several reasons may explain the difficulty in achieving effective canine rabies control: the shortage in financial and/or human resources; the inaccessibility to a large fraction of the dog population, the high turnover rate of dog populations; and the non respect of the vaccine cold chain.

Any attempt to control rabies in North Africa can only be through canine mass vaccination with accompanying measures such:

- Generalizing laboratory confirmation of suspected rabies cases and standardization of laboratory diagnosis techniques.
- Increasing public awareness towards rabies for a better adherence of the local populations to rabies vaccination campaigns.
- Sensitizing human and animal health professionals.
- Improving knowledge on the size of dog population and its dynamic.
- Assessment of the vaccination coverage.
Despite the preventability of rabies, the disease has progressively expanded in dog and other carnivore populations of sub-Saharan Africa over recent decades. Although rabies is a notifiable disease in the majority of African countries, it is easily neglected as it often oscillates in a disconnected fashion between authorities concerned with either human or animal health. Given a disconcerting lack of epidemiological surveillance and inconsistent reporting to regional and global structures, the objective of eradication will always be difficult to justify on national agendas or to global funding agencies.

On a continental level, the One Health approach has already been shown to be successful towards dog rabies control in at least one part of the developing world, when implemented by PAHO in Latin America. In contrast, there is no pan-African approach to rabies control, although small regional efforts present hope. The rabies control program in Kwa-Zulu Natal (KZN) in South Africa, supported by the Bill and Melinda Gates Foundation, celebrated a year free of human rabies on 24 June 2011. That occasion constituted the first time in 20 years that KZN has not recorded a single human death from rabies in a full calendar year. This is, however, a very small victory in the face of the continent-wide challenge. We suggest that the road to an effective strategy for rabies control in Africa starts with a pan-African approach towards establishing sound surveillance and reporting structures. Clearly, only a sustained and reliable demonstration of the extent of the disease burden will allow for an elevated priority given to rabies on national and global agendas. The success of such a venture is certain to be conditional to the synchronized guidance and support of the OIE, WHO and other global partners in the One Health paradigm.
CASE REPORT (7) – REPUBLIC OF KOREA
EPIDEMIOLOGICAL CHARACTERIZATION OF RABIES IN KOREA SINCE 1971

Yang D.K. & Song J.Y.
Viral disease division, Animal Plant and Fishery Quarantine Inspection Agency, Anyang, Republic of Korea

Over the forty years from 1970 to 2010, 872 rabies cases in four different animal species were recorded in Republic of Korea. The highest annual incidence of rabies was recorded with 91 cases in 1975. At that time, the Korean government carried out rabies control programs. No case was reported for 8 years from 1985 to 1992. After a recurrence of the disease was noted in Gangwon Province in 1993, continuous rabies cases were observed during the period 1993 -2003 (331 cases). To prevent rabies occurred by wild animal, oral bait vaccine had been applied to the occurrence locations. After application of bait vaccines, the annual rabies seemed to have decreased in 2004 – 2010. Recently, all rabies cases occurred in the northern part of Republic of Korea and since 2007, rabies cases were not identified in Gyeonggi Province but continue to occur and moved eastward in Gangwon Province. The nucleoprotein (N) of many Korean rabies virus (RABV) isolates collected from animals diagnosed with rabies was subjected to molecular and phylogenetic analysis. The similarities in the nucleotide sequence of the N gene among all Korean isolates ranged from 98.1 to 99.8%. Based on the nucleotide analysis of N gene, the Korean RABV isolates were classified into four district subgroups with high similarity. Phylogenetic analysis showed that the Korea isolates were most closely related to the eastern China. The epidemiological study indicated that the Korean RABV isolates originated from rabid raccoon dogs in Northeastern Asia and appropriative preventive measures including mass vaccination, slaughter of stray dogs and distribution of bait vaccine for the control of animal rabies was helpful to a substantial decrease in numbers of rabies cases in the Republic of Korea.
NEW DIAGNOSTIC TOOLS FOR RABIES IN ANIMALS

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Rabies is routinely diagnosed in animals based on clinical signs and on epidemiological grounds in rabies-endemic countries. Negative diagnostic tests using conventional assays, even late in the disease, do not exclude the clinical diagnosis as these tests can be sub-optimal and are entirely dependent on the nature and quality of the sample supplied. The use of conventional OIE-prescribed diagnostic tests including the fluorescent antibody test (FAT) and the rabies tissue-culture infection test (RTCIT) can now be complemented with molecular diagnostic tools, advanced histopathology and serological assays. Molecular tools especially RT-PCR methods and virus typing are increasingly used for the rapid detection of viral nucleic acid in clinical samples. A pan-lyssavirus PCR offers detection of all recognised lyssaviruses. In addition, the development of a single, closed tube, RT-PCR TaqMan assay distinguished between strains of rabies virus in real time. The TaqMan assay is rapid, sensitive, specific and allows for the genotyping of unknown isolates concomitant with the RT-PCR. In addition, our ability to detect virus in tissue other than brain has been enhanced by using a variety of histopathology techniques, including immunocytochemistry and in-situ hybridization. For serological testing, we have developed retroviral vectors that can be used in neutralisation assays to determine antibody titres for rabies virus. The challenges in the 21st century for diagnostic test developers are two-fold: firstly, to achieve internationally accepted validation of a test that will then lead to its acceptance by organisations globally. Secondly, the areas of the world where such tests are needed are mainly in developing regions where financial and logistical barriers prevent their implementation. These barriers are not insurmountable and it is our expectation that if such tests are accepted and implemented where they are most needed, they will provide substantial improvements for rabies diagnosis and surveillance of this disease.
NEW DEVELOPMENTS IN RABIES VACCINES

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Since 1885 and the first application to Joseph Meister of the original Louis Pasteur’s vaccine, “vaccinology” has become a specific topic in science to which rabies has predominantly contributed. The Pasteur’s type of vaccines, produced on animal nervous tissues, are no more recommended by WHO due to potential adverse effects and their use has significantly diminished since 15 years. They have been progressively replaced by safer and more immunogenic vaccines purified from cell culture supernatants that are produced by companies from developed or emerging countries. Under an inactivated form, these vaccines are used for pre- and postexposure treatment in humans as well as for parenteral vaccination of domestic animals with possible adjuvant.

In the developed world, the systematic vaccination of dogs and the consecutive disappearance of dog rabies has led to the “emergence” of wildlife vectors in the epidemiological landscape, mainly carnivores and chiropters. New “replicative” vaccines have thus been developed for oral vaccination of wildlife, either attenuated rabies viruses or recombinant vaccines using different viruses (vaccinia virus, adenovirus, etc) expressing the rabies glycoprotein. Introduced in convenient baits, these replicative vaccines have succeeded to eliminate fox rabies from Western Europe, demonstrating once again the reactivity of the rabies community, from scientists to industrials, veterinarians and field workers.

Despite these constant progresses, new challenges are still ahead to improve rabies vaccinology and several of them will be discussed:
1. how to increase the spectrum of protection of classical anti-rabies vaccine to divergent Lyssaviruses that have been evidenced in bats. All vaccine strains currently used are from classical rabies virus genotype 1.
2. is oral vaccination a realistic complementary approach to parenteral vaccination for stray dog populations
3. can we still innovate in recombinant vaccines
4. may vaccines combine rabies antigens with other immunogens (different antigens, immunomodulatory or immuno-contraceptive molecules, ...).
CRITERIA FOR THE USE OF PARENTERAL AND ORAL IMMUNIZATION OF DOGS

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Preventive vaccination against rabies virus is a highly effective method for preventing rabies in animals and humans. Systematic and large scale use of injectable vaccines in dogs in combination with dog movement restrictions have contributed to the progressive disappearance of canine rabies from Western Europe and the United States by the middle of the last century and more recently, large extends of these areas have been freed of wildlife rabies by oral vaccination.

Tragically, rabies continues to claim more than 55 000 human lives each year, mainly in the sub-Indian continent, Asia, Africa and Latin America and this in spite of widespread efforts to control the disease in dogs and the availability of safe and efficacious rabies vaccines.

In addition to strong political focus and good rabies awareness in the human population, accurately understanding rabies epidemiology and clearly defining ways by which to gain access and optimizing the vaccine coverage in the targeted dog population, all while preserving vaccine quality for an optimal immune response of individual dogs throughout the vaccination campaigns are critical elements of successful rabies control and will be discussed.
IMMUNO-CONTRACEPTION AS A TOOL FOR RABIES AND DOG POPULATION CONTROL

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Appropriate animal management is critical in control of neglected zoonoses, including rabies. Experience has demonstrated significant ecological, economical, and ethical limitations to lethal population reduction of rabies virus reservoirs, including dogs. Consistent utilization of pure, potent, safe, and efficacious vaccines results in elimination of canine rabies. Development of novel tools for burgeoning canine populations could simplify attempts at vaccinating against rabies, broadening herd immunity, altering animal reproduction, and gaining broader public acceptability. One product, GonaCon, incorporating adjuvant and gonadotropin-releasing hormone (GnRH), has been used as an immunocontraceptive in mammals, including dogs. As a preliminary evaluation of dual contraceptive-rabies vaccines, effects of GonaCon on rabies virus neutralizing antibody induction had been evaluated, via co-administration of commercial rabies vaccine in dogs. Combined use of GonaCon did not affect canine seroconversion. Given these results, using reverse-genetics, GnRH coding sequences were inserted within the rabies virus ERA glycoprotein (G) gene. The amino terminus (N), antigenic site Ila, and junctions between the ecto- and cytoplasmic domains (C) of the G gene were found suitable for GnRH insertion. Rescued recombinant viruses, ERA-N-GnRH and ERA-C-GnRH, replicated as well as parental virus. Expression of GnRH appeared stable in recombinant viruses after multiple cell passages. To increase immunogenicity, two copies of GnRH, aligned in tandem, were fused to the N terminus of rabies virus G. Recombinant viruses reacted with serum from GonaCon-immunized animals. All GnRH-recombinant viruses induced antibodies against GnRH in mice, and protected vaccinated animals against rabies virus challenge. Significantly, fecundity in ERA-2GnRH vaccinated mice was reduced by 80%, in contrast to 90% conception in unvaccinated controls. By inference, these data should extrapolate to other mammals, including dogs. Besides focused community education efforts on responsible animal ownership, development of biologics that contain contraceptive and rabies virus antigens may provide substantive enhancement in disease prevention and population control.
REASSESSMENT OF THE SOCIO-ECONOMIC GLOBAL BURDEN OF RABIES: HUMAN AND ANIMAL COST OF GLOBAL RABIES

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Rabies remains a low priority for the global public health community, despite the feasibility of control and potential for elimination. A lack of accurate data on the burden of rabies contributes to this neglect. In an effort to redress this balance, we have launched a global survey amongst stakeholders in rabies control and prevention and are reviewing published literature with the aim of re-assessing the global burden of canine rabies. This research highlights knowledge gaps in key parameters (exposure incidence, probability of bite-victims receiving post-exposure prophylaxis, and prevalence of rabies in animal populations) and geographical regions (North and Central Africa, China, Central and South Asia) where data is sparse or cannot be reliably validated. Nonetheless, we identify significant correlations between key epidemiological parameters and socioeconomic attributes and use these to parameterize a probabilistic model to quantify the burden of rabies with country data or cluster averages. The model suggests that the death toll from rabies is greater than all other zoonoses and that the global burden of rabies in disability-adjusted life-years exceeds that of schistosomiasis, trypanosomiasis, onchocerciasis and dengue. The study generates a number of location-specific predictions that could be tested with active surveillance studies, and provides guidance for future research and prioritization of strengthening control efforts. Critically, the model draws attention to the relationship between investment in rabies control in the animal sector and concomitant reductions in human rabies and expenditure by the public health sector. Overall these findings demonstrate the magnitude of the burden of rabies and the substantial reductions in human suffering and economic savings possible through multisectoral and political commitment towards rabies control.

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**IMPACT OF ANIMAL RABIES ON LOCAL ECONOMY**  
**PART I: ON LIVESTOCK AND WORKING ANIMALS**

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In countries where rabies is present, livestock and other working animals can become infected with the rabies virus. Livestock is an important source of food and income globally and working animals contribute to livelihoods particularly of livestock dependent poor in many parts of the world. Working animals are not limited to cattle, buffaloes, horses, donkeys and camels for plowing the fields and transportation of people and goods as dogs are used for hunting, herding livestock, assisting military and police forces and guarding property. Moreover in some cultures, the consumption of dogs is a common practice.

Deficient surveillance and the lack of reliable data on the number of rabies cases is a major constraint to assessing the economic impact of rabies on the local economies when livestock and working animals die due to rabies or infect humans. In addition, the need to pay for transport and expensive post-exposure prophylaxis for rabies exposed family or community members can lead to the unplanned sale of production animals and livelihoods assets, further impacting food and economic security.

The epidemiology of rabies in livestock and working animals varies geographically. Changing land use and reforestation has led to the expansion of areas where livestock have increased contact with rabies infected bats and wildlife. Vampire bat rabies especially impacts livestock production in Latin America while in Eastern Europe and Asia, livestock and working animals are more readily infected by other wildlife such as foxes, jackals and wolves. In Africa, dogs appear to play an important role in the transmission of the disease to transport animals especially in urban and peri-urban areas. Improved surveillance and a clear picture of the economic and public health impacts of rabies on the national and local economies would contribute to more appropriate allocation of resources and the urgently needed political will.
There is no doubt that canine rabies control has the potential for enormous public health benefits, not only reducing the number of human rabies deaths, but also the demand for costly post-exposure prophylaxis. However, control of animal rabies also has broader societal impacts, with benefits for both human and animal populations affected by the disease. Rabies is a disease that elicits great fear and distress, both as a result of uncertainties faced by those requiring post-exposure prophylaxis in impoverished and remote rural communities, and as a result of the psychological trauma involved in managing human rabies cases. More recently, rabies has become a concern for the tourism industry with travel advisories issued in countries experiencing a reintroduction of rabies or on-going endemic disease. Imported cases of human rabies, although rare, highlight a continuing lack of awareness among travelers of the disease risk in canine rabies-endemic countries. Additional impacts of animal rabies control include benefits for animal welfare, with improved attitudes and treatment of dogs, and benefits for wildlife conservation, with mass dog vaccination recommended as part of conservation strategies for wild carnivore populations threatened by canine rabies. Awareness of the multiple benefits of animal rabies control not only provides added justification for rabies control initiatives, but also broadens the constituency for support, offering the potential for developing integrated control measures that involve veterinary public health, tourism, wildlife conservation and animal welfare agencies.
COST OF NATIONAL RABIES ERADICATION PROGRAMMES

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Following new research activities in the mid-70s aimed at immunizing foxes against rabies via oral vaccination, it was possible for the first time from 1983 onwards to draw closer to the objective of eradicating rabies via oral vaccination of foxes. This method of rabies control became practicable in 1989. From autumn 1989 until spring 1992, a total of 19.6 million vaccines baits were placed in Germany (~ 21 million €), 987,000 vaccines baits in Austria (~ 1 million €), 485,600 vaccine baits in Czechoslovakia (1989/1990, ~506,000 €) and 1.44 million vaccine baits in the former GDR (1989/1990, ~1.53 million €). In 1993 Germany continued with the oral vaccination programme of foxes (approx. 8 million baits; costs approx. 8 million €). Once it was possible to produce machine-made vaccine baits, large-scale oral immunization campaigns were launched to control rabies in foxes. From 1994 onwards, the measures (purchase of the vaccine baits) were co-financed by the European Community through Decision 90/424/EEC of 26 June 1990 on the basis of a plan submitted by the Member States. A total of 24 million baits (~ 21 million €) were placed in Germany between 1994 and 1996. These costs also included the delivery and documentation costs.

The former third countries Poland and Czech Republic were included in the German plan from 1997 to 2003 with Germany financing 50 % of the costs incurred in these two countries. Germany placed a total of approx. 26.2 million baits between 1997 and 2003 (approx. 19.2 million €). Over the same period, some 8.5 million baits (~ 3.2 million €) were delivered in Poland and some 4 million baits (~0.94 million €) in the Czech Republic. An additional 6.9 million baits were delivered in Germany from 2004 until the last round of delivery in spring of 2008 with total costs of 5.2 million €. This means that the total costs for purchasing baits, delivery and documentation in Germany alone amounted to approx. 75.9 million €. These total costs for purchasing baits, delivery and documentation rise to approx. 85.3 million € when also including the expenses during the early years of rabies control (1983 – 1988).

This amount does not include the costs for accompanying tests which amounted since 2000 to a total of approx. 17.4 million € and were financed by the public sector. The European Community contributed to these costs only from 2007 onwards (2007 with 23,237 €, 2008 with 18,907 € and 2009 with 16,512 €).

Costs continue to incur even after Germany has been officially declared as a country free from rabies to document this rabies-free status via a serosurveillance and also to be able to detect a rabies infection early on. All of these costs are borne by the public sector.
OIE STANDARDS AND SCIENTIFIC ACTIVITIES FOR RABIES CONTROL

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Veterinarians are key public health stakeholders because of their crucial role in: Promoting food security by supervising animal production, monitoring food quality and safety, advancing biomedical research and controlling zoonosis at the animal source to create a buffer between the animal source of the disease and susceptible human beings - in line with OIE’s overall mandate to improve animal health, veterinary public health and animal welfare world-wide.

Already in 1928, the OIE Members around the globe adopted a resolution dedicated to rabies. These strong recommendations called for a better commitment of governments for rabies control, including collaboration with the public health sector and international harmonisation in rabies control and eradication at the animal source. This set of recommendations included guiding principles, such as international, cross-border collaboration in rabies elimination, the duty of veterinarians towards the public health impact of rabies, confinement of rabid and suspect animals, conditions for using rabies vaccines in animals and countries’ annual reporting to the OIE on the epidemiological rabies situation. Many aspects of these guiding principles are still considered valid pillars of today’s strategies in the fight against rabies on which OIE has been closely collaborating with its international partners.

The OIE provides science-based standards, guidelines and recommendations for the control of the disease in animals and to prevent the international spread of rabies, as well as standards for the diagnosis and the preparation of quality vaccines for use in animals. Through its capacity building programmes, global and regional conferences and its scientific network consisting of Specialists’ Commissions, Reference Laboratories and Collaborating Centres, the OIE supports veterinary services with policy advice, technical assistance for the diagnosis, control and eradication of rabies. An update on recent revisions and new concepts in OIE standards and activities will be provided.
WHO STANDARDS FOR RABIES CONTROL (PREVENTION OF HUMAN INFECTION, PROFESSIONAL HAZARDS)

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Veterinary and medical practitioners, animal welfare personnel, zoologists and animal conservationists, laboratory scientists are some of the groups which must absolutely be aware of the nature of the risk and modes of transmission of rabies.

Clinical manifestations can vary in rabid human and animals. Rabies virus can be shed in saliva and other biological fluids even before first symptoms are noticeable. During the clinical phase rabies virus is found in virtually all tissues of an infected animal and human. It remains potentially viable for days at room temperature and longer if refrigerated or frozen. It may under certain conditions aerosolizes and become a great hazard if inhaled or swallowed.

Rabies is usually transmitted by bites of rabid animals mainly domestic and wild carnivores as well as bats but handling rabies infected livestock species may occasionally transmit rabies. However more than 95% of the 55,000 human rabies deaths estimated to occur annually in the world follow a rabid dog bite and are originating from Africa and Asia. Human deaths from rabies associated with wildlife species including bats are very rate in comparison.

Risk in professionals may occur particularly when performing unprotected necropsies or autopsies. These can all be avoided by using basic protective measures generally available in a clinic or hospital. The use of mask, gloves and a gown as well as glasses when examining and handling a rabies suspected patient and conducting necropsies/autopsies is mandatory. This should protect staff from droplet infection to face and eyes, sites at greatest if not only risk.

Professionals, who are likely to be exposed to the live rabies virus through their work, should receive pre-exposure vaccination. This include veterinarians, veterinary technicians working in rabies infected areas, particularly those directly involved in mass vaccination campaigns of dogs and wildlife and laboratory personnel handling suspect samples, animals and live rabies viruses. This, under current WHO guidelines, consists of one intramuscular full dose or intradermal of 0.1 mL dose of tissue cultured or embryonated egg vaccine on days 0, 7 and 21 (or 28). Boosters are justified only in individuals who are at continuing risk of exposure to live virus and shown to have rabies titre less than 0.5 IU/mL at 6 months periodic check. There is no need to have booster in any other groups unless there has been a possible exposure. In case of exposure a short post-exposure prophylaxis without immunoglobulin consisting in 2 doses of vaccines on day 0 and 3 should be administered either intramuscularly or intradermally. As an alternative 4 intradermal injections of 0.1 mL can be provided on day 0.

Intradermal application of rabies vaccines for pre-exposure prophylaxis in professional groups at continuing risk of contracting rabies particularly those involved in mass vaccination campaigns is strongly recommended by WHO in places where vaccines access may be limited as it is as safe and efficacious as the intramuscular route and much more economical as immunization sessions can be scheduled in advance.
OTHER RELEVANT INTERNATIONAL STANDARDS

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While it is clear that in most cases, the most effective approach to preventing
and controlling rabies is to reduce the incidence in domestic animals and thus
preventing human infection, complete control in many situations still requires
efforts targeted at controlling the disease in wildlife. Several international treaties
created to protect natural resources in general and threatened, endangered
and migratory species in particular may affect rabies management approaches.
Most relevant are the Convention on International Trade in Endangered Species
of Wild Fauna and Flora (CITES), the Convention on Migratory Species (CMS),
the Convention on Biodiversity (CBD) and the Ramsar Convention. Such treaties
may present both benefits and challenges to rabies control programs, especially
as several species and species groups considered under the treaties are also
susceptible to the rabies virus. By encouraging or mandating the protection
of species and habitats, the treaties may limit the harm done otherwise to
already-vulnerable species or ecosystems that could result from population
eradication rabies control efforts. At the same time, international regulations
around the protection of endangered, threatened or migratory species may
present impediments for rabies control programs by limiting rabies intervention
options, potentially presenting greater opportunity for the spread of the virus in
wildlife populations.

Rabies has been increasingly documented in wildlife populations, presenting
a serious risk to the management and conservation of affected animals. The
rabies virus has been documented in over 120 mammal species. The dynamic
epidemiology of the virus and its global presence has made it a growing concern
for wildlife managers as well as public health and agriculture authorities, and
the general public. Given the added complexity of disease management in
wildlife and the additional regulations that govern wildlife and wild lands,
solutions for controlling rabies requires the engagement of a broad range of
both stakeholders and expertise.
INTERNATIONAL MOVEMENT OF PETS: INDIVIDUAL IDENTIFICATION, PET PASSPORTS, TRACEABILITY, QUARANTINE AND SANITARY CONTROLS

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Rabies is a notifiable disease in all Member States of the European Union (‘EU’). EU-supported oral vaccination programmes have been implemented since the early 90s and have substantially reduced the incidence of the disease in wildlife, and consequently in domestic dogs and cats, and gradually eradicated the disease in large parts of the EU.

Although the incidence in humans is very low in Europe, fatal outcomes following dog bites in travellers returning from countries with urban rabies are still documented and sporadic reports of rabies cases in illegally introduced dogs continue to require vigilance.

In 2003, due to the improved situation with regard to rabies, the EU adopted a set of health rules (referred to as the ‘Pet Regulation’) which aim at facilitating the cross-border movement of pet animals while safeguarding animal and public health.

These rules provide that pet animals accompanying their owner and entering or re-entering a Member State from another Member State or certain listed third countries are to be identified with an electronic microchip or a tattoo applied before 3 July 2011 and be accompanied by a passport or an animal health certificate documenting a valid anti-rabies vaccination certified by an authorised veterinarian.

Entry from third countries with a higher risk of rabies is subject to complementary verification of a protective immunity by testing against the WHO threshold titre of 0.5 IU/ml for neutralising antibodies and a subsequent waiting period to allow the development of clinical signs in possibly incubating animals.

The Pet Regulation does not apply to national movement within a Member State. However, electronic identification of dogs and in some cases their registration may be mandatory in some Member States for purposes other than animal health and compulsory vaccination of dogs and cats may be part of an eradication programme in Member States with sylvatic rabies.

Transitional measures in the Pet Regulation that allow certain Member States to continue the application of national rules are due to expire on 31 December 2011. In order to prevent movement of non-eligible pet animals, documentary and identity checks are to be carried out at designated travellers’ points of entry for pet animals coming from third countries. A series of action is foreseen in case of non-compliance with the requirements of the Pet Regulation.
MONITORING AND CONTROL OF DOG POPULATIONS

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Stray and feral dogs pose serious human health, animal health and welfare problems and have a socio-economic, environmental, political and religious impact in many countries. Human health, including the prevention of zoonotic diseases, notably rabies, is a priority. Dog population management is an integral part of rabies control programmes. Rabies is one of the important zoonotic viral diseases which infect human and animals. WHO recorded that, this disease kills more than 55,000 human each year. OIE guidelines recognized the importance of controlling dog populations without causing unnecessary animal suffering.

Although killing is apparently a less expensive method of dog control, it brings about many animal welfare concerns, particularly in light of the widespread use of poisoned baits and shooting by personnel not enough trained. Experiences in developing countries have shown that removal of stray dogs by these methods has little or no impact on population densities, because losses are easily compensated by increased survival in the populations that remain. Therefore the control of the dog population should be within a programme including a group of actions.

To assess the problem and monitoring of the dynamic of dog populations on a national level, is a key element in adopting a sustainable and successful plan for monitoring and control dog populations, which includes: Suitable and applicable legislation including OIE guidelines; elimination of garbage, and edible wastes of houses, abattoirs, and restaurants; reduce the introduction of new dog population, available facilities and logistics; awareness campaign; good training and clear SOPs; intersectoral collaboration between public and private veterinarians, municipalities, media, mosques and churches, human health authorities, social experts, etc.

Veterinary Services should play a lead role in preventing zoonotic diseases and ensuring animal welfare and should be involved in dog population control, coordinating their activities with other competent public institutions and agencies.
VETERINARY SERVICES AND THE VETERINARY PROFESSIONALS IN RABIES CONTROL

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Veterinary medicine has made many significant successes in the field of animal health from the days when animal disease control was wrestled from the hands of priest, leech-doctors, furriers and quacks.

Veterinarians, in many sectors of human endeavor, are contributing in various ways to the eradication of rabies. In addition to their well-known role as animal doctors, veterinarians have proved their ability to design programmes for the prevention and control of infectious diseases, including those transmissible to humans. The veterinary profession’s contribution to public health is now universally acknowledged as vital.

The Commonwealth Veterinary Association (CVA) builds awareness and understanding in the veterinary profession which utilized for better professional competence in the surveillance of and preparedness for serious animal disease, both emerging and re-emerging through greater sensitization. The CVA projects are designed to develop capacity of veterinarians. They also serve as models for possible implementation throughout the Commonwealth and beyond. Research by Veterinarians and current activities of veterinary services both, in the private and government sectors support the fact that veterinarians have a major role to play in the control of rabies.

This presentation looks at the efforts of Government’s Veterinary Services, Private Veterinary Practitioners and Veterinary Associations in the control of rabies. The paper particularly would share the findings of a Commonwealth Veterinary association rural rabies project to demonstrate the effectiveness of combined and coordinated Medical and Veterinary intervention of rabies control in West, East, Central and Southern Africa.
INTER-SECTORIAL COLLABORATION AND DOG RABIES CONTROL

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LOCAL GOVERNMENTS, MUNICIPALITIES AND DOG RABIES CONTROL

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Over the past 44 years KwaZulu-Natal (KZN), a province on the eastern seaboard of South Africa, has been battling endemic canine rabies. Given a system of solid regulations, good surveillance and sound veterinary infrastructure, there has been some success in the control of rabies. Elimination of the disease has however eluded the efforts of the programme. This paper aims to elucidate the factors, events and circumstances that played a role in the successes and disappointments in the effort to control rabies in KZN. Most recently, with international support and sponsorship (Bill and Melinda Gates foundation/WHO), the KZN Rabies project has taken significant steps in the direction of an ultimate goal of rabies elimination.

In this paper, we analyse the role of local governments and municipalities, communication strategies and program sustainability within the context of the current project and the history of rabies control in the province. As can be expected, we demonstrated that it is essential to determine the true extent of herd immunity within the KZN dog population, which is in turn determined by the methods and approaches used in the mass vaccinations campaigns. We could demonstrate that failures resulted from institutional pressure on the rabies control programme. These include political pressures, financial constraints, poor management and shifting priorities (outbreaks of other diseases of economic importance etc.)

Successes on the other hand, were largely dependent on the establishment of a core team of capable and motivated individuals. It appears that, in a setting such as KZN, the sourcing of committed and passionate individuals at the local level has been a key component in the creation of a platform from where the elimination of rabies has a realistic chance, regardless of the significant constraints and challenges prevalent in the developing world.
RABIES CONTROL AND ANIMAL WELFARE

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The welfare of animals in countries in which rabies is endemic is frequently ignored. This is largely because of the gravity of the human health problem and this, combined with an ignorance of the best methods to control the disease and hence protect human health, can, and often does, result in extreme animal suffering.

Rabies itself causes great suffering in animals, farm animals, wildlife, cats and dogs, as it does in humans.
The OIE Guidelines on stray dog population control lay down practical and humane ways to control rabies in the stray and owned dog population.

One of the problems that needs to be overcome is the attitude of the authorities – veterinary services, national and local competent authorities and police – towards stray animals, both cats and dogs. It is important that these authorities are persuaded of the need for a holistic approach to dog control and not to propose poisoning and slaughter of dogs as the only solution. Vaccination programmes for animals, particularly dogs, is a vitally important control measure and whilst it may appear expensive at the time will eventually prove to be economically beneficial.

This paper will demonstrate how changing the socio-economic and public health attitude towards rabies control and animal welfare and, in some instances, eradication can be achieved.

Controlling, and eradicating, rabies is not impossible and if achieved, will have enormous economic as well as human and animal health benefits.
ANIMAL HABITAT AND ENVIRONMENTAL FACTORS

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Animal habitat and environmental factors influence local rabies situations primarily through the suitability of habitat for sylvatic or feral reservoirs/vectors of rabies and through opportunities that the habitat and environment may provide for interactions between rabid animals and susceptible humans, wild, and domestic animals. Landscape and natural barriers can influence spread of rabies, as illustrated by the sylvatic rabies progression in Europe. The introduction and establishment of populations of dogs into an environment, especially under rural conditions where contact with native wildlife is more likely, may cause problems not only for the wildlife via predation, competition, or disease introduction, but also can increase the likelihood of human rabies exposure. Human contact with dogs is more likely than contact with wildlife, and feral or stray dogs are less friendly and more likely to bite, particularly if they are protecting food sources or litters of pups. In addition to the direct means of reducing problematic dog populations by direct manipulation of the dogs, indirect methods should be employed to keep dog populations small, or to exclude dogs from specific areas. Indirect methods often are centered on removal of food or other items that attract dogs to an area. Making rubbish dumps and garbage from households, restaurants, food markets, and abattoirs unavailable to roaming animals is a critical component of any (wild or domestic) animal population control program. In fact, actual removal of dogs is documented to be much less effective than reducing the carrying capacity of the habitat through removal of food sources, because dogs that are removed will be replaced by dogs that migrate from other areas to fill the void and utilize the food source. Regardless of the method employed, all dog population control programs must have an effective public education campaign in order to have any chance for success.
Although rabies is considered to be a totally preventable disease, every year over 55,000 human deaths occur most of which resulted from exposure to an infected dog. Almost every one of these human deaths occurred due to a lack of educational awareness about how to prevent rabies. Dog bite victims often seek treatment from local healers instead of visiting an anti-rabies clinic, governments often do not understand the cost-savings implications of instituting dog vaccination programs, children and their families lack awareness about the importance of responsible pet ownership, etc. Improving educational awareness about rabies control and prevention on all levels of society has proven to be a successful and valuable tool in reducing the number of dog bites and rabies cases. Rabies prevention educational programs have been launched in many countries as a direct result of World Rabies Day, held annually on September 28, the anniversary of the death of Louis Pasteur. Education is the first key to instituting behavioural change in communities that have previously not taken action to reduce the incidence of rabies in their neighbourhoods. The keys to changing the behaviour of dog owners that traditionally do not care for their animals include initiating discussions with the community to determine what it is that they want to accomplish regarding rabies control and then helping them to design a strategic plan to accomplish the goal. In order to establish a sustainable program, it is essential to establish a working group that includes all stakeholders that will ultimately be involved in the rabies prevention and control plan. This generally includes both the veterinary and medical profession at the Ministerial levels as well as representatives from the Ministries of Education, Finance, Environment and Legal. Mass public awareness campaigns are essential for securing the support of the citizens that will ultimately need to change their behaviour in order to make the program a success. There are many resources available to help initiate a rabies control program including the Blueprint for canine rabies elimination and human rabies prevention (www.rabiesblueprint.com).
COMBINING DOG RABIES CONTROL PROGRAMMES WITH OTHER INTERVENTIONS TO CONTROL ANIMAL DISEASES – OPPORTUNITIES AND CHALLENGES

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Inadequate supplies of financial and personnel resources impact the delivery of human and animal health services in most developing countries. Large distances and poor road infrastructure represent further challenges, necessitating new methods to ensure comprehensive provision of health services. Joint animal and human health studies in pastoralist communities have shown that veterinarians engaged in livestock vaccination programmes achieve better coverage than human health personnel. Trials done in Chad over several years showed that combining human and animal vaccination services is feasible and conserves financial resources when compared to single sector campaigns. However, such approaches are deeply context-dependent, requiring careful insight into community socio-cultural and provider aspects. Participatory stakeholder approaches, which involve local communities, authorities and technical experts, allow for identification of local priorities for disease control in animals and humans. Tailoring interventions to the needs of the communities optimizes the use of scarce resources and may lead to unexpected collaboration across sectors of public services. Using this type of approach, rabies control would be integrated into an overall animal and human health approach not addressed using a single sector vertical operation. Rabies vaccination of dogs could be incorporated in joint human and animal vaccination campaigns for remote rural populations in Africa or be part of brucellosis mass vaccination efforts in Central Asia and Mongolia. Consequently, remote populations could be reached more efficiently, with significant reduction in intervention costs, hopefully to affordable levels. Additional contextually-adapted, community-based studies are needed to substantiate technical and economic evidence for inclusion of rabies control into other animal and public health interventions, possibly as an extension of the Blueprint for Rabies Prevention and Control (rabiesblueprint.com). Remote rural communities could also contribute more effectively to wildlife rabies prevention and control.
Canine rabies is responsible for approximately 55,000 human deaths each year with more than 99.9% reported in Asia and in Africa. Each human death is entirely preventable since vaccines and other biologicals are available. Canine vaccination programmes appear as the effective tool to control rabies in those countries where dog is the reservoir and vector of the disease. The ultimate objective of rabies vaccination strategy is to prevent rabid animals from transferring rabies virus to humans, to protect them if exposed to rabies virus and to interrupt the transmission from one animal to another one. To be efficient, the vaccination coverage should be 70%, in most cases this level is not achieved because dog rabies control is not a priority. The knowledge of the local dog population is a pre-requisite to efficient rabies control policy. This knowledge is also useful to control other dog mediated diseases as hydatidosis, and leishmaniosis. Information campaigns about rabies and its control increase awareness and contribute also to the success of dog vaccination programmes.

In areas where regular and long term control efforts target dog thanks to strong commitment from national authorities, current mass vaccination programmes are successful and elimination of canine rabies is nearly achieved. A number of WHO consultations have been organized since several decades and concrete recommendations and road maps are available for planning, implementing and evaluating the strategy of rabies control in dog populations. Three large-scale rabies elimination projects (KwaZulu Natal, Tanzania and Philippines) supported by the Bill and Melinda Gates Foundation in cooperation with WHO were initiated in 2009 aimed on mass vaccination of 3 million domestic dogs. Approaches towards dog rabies control using effective rabies surveillance network and vaccination strategy will be detailed and discussed.
Funds for disease control programs are traditionally sourced from local and national governments, and international development aid. Because rabies control is often not among the disease priorities of the public health nor agriculture ministries, mobilization of resources for effective comprehensive implementation has always been a challenge. On the other hand, being a disease that crosses different sectors of society and diverse fields of discipline, a number of rabies control programs in humans and animals have sourced funds from different sectors at different levels, from the grassroots to the corporate and civil society organizations.

Actual implementation of intersectoral rabies control programs often require and depend on a regular budget allocation as mandated by law. Field implementers and partner communities may face constraints such as high operational cost, wide regions of coverage and labour intensity. Many innovative approaches have been attempted to overcome these problems.

A recent example of a successful, sustainable community-based integrated rabies control program is the Bohol Rabies Project, implemented as a partnership between the Provincial Government of Bohol, Philippines and the Global Alliance for Rabies Control (GARC). The estimated operational cost was USD 498,000 over 4 years. Cost sharing by different stakeholders was achieved through mobilization of financial and human resources. GARC contributed 33% through funds raised from socio-civic partners. The Philippine Government contributed 60% in collaborative funds. Remaining funding came from the WHO Country Office and local NGOs. Community volunteers were organized to augment the human resource requirement. Funds were generated by the communities through collection of dog registration fees, all of which were re-invested back to establish a self-sustaining funding stream. Sustainable and meaningful field operation was realized when actual acceptance and ownership of the program at the community level was achieved. Attaining the goal of rabies control and eventual freedom from disease became a shared concern.
COST-BENEFIT ANALYSIS OF RABIES CONTROL

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Rabies control in developing countries is often poorly organized as a result of poor communication between the human and animal health sectors. Ministries operate with a narrow focus; for example, the Ministry of Health is unwilling to assume responsibility for an intervention outside of the public health sphere and the Ministry of Agriculture and Livestock prioritises cattle over dogs and wildlife. Neither is willing to allocate scarce resources to address a disease which is not their priority. An economic analysis of rabies control provides a framework to examine the benefits and costs of intervention. Benefits in terms of saved resources and human and animal lives across all affected public and private sectors can then be compared to intervention costs, considering potential sharing across sectors. Typically, interventions in dogs and wildlife translate into saved human lives in a non-linear way. Presented here is a cross-sector public and animal health economic approach to rabies control which is based on a dog-human transmission model linked with a cost-effectiveness analysis. It can be adapted to specific contexts and matched with the Blueprint for Rabies Prevention and Control (rabiesblueprint.com). Benefits in terms of saved human post-exposure treatment cost can be compared to costs for mass vaccination of dogs. Savings in human lives are expressed as saved years of life lost (YLL). Use of transmission models requires sufficient data for dogs, wildlife and humans collected over extended time periods and integrated study designs across human and animal health. Further extensions would include dog population management and wildlife conservation. The concept of benefits must then be expanded to value the lives of companion animals and wildlife conservation, both of which are part of ecosystem “integrity”. The result is movement into ecosystem-health approach to rabies control. Human-animal relationship is strongly determined by culture and religion. These influence animal populations and, therefore, indirectly rabies transmission, illustrating the complex interplays between natural science and humanities and supporting system dynamic approaches of health in social-ecological systems (HSES).
MAINSTREAMING RABIES PREVENTION AND CONTROL AT NATIONAL LEVEL: FOCUS ON THE ROLE OF THE NATIONAL VETERINARY SERVICES

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The prevention and control of rabies, as is the case in many of the other zoonotic diseases, calls for an equal responsibility by both the animal health and human health professions. However, in many countries there still appears to be a never-ending debate between Ministries of Health and Agriculture on who is responsible for what? The end result of many of these debates is that dog owners are perceived and accepted to be responsible for having their animals vaccinated or to prevent them from having contact with infected animals and that should this not be attainable, then the human health profession should take the costly responsibility for treating the unfortunate victims of the disease. Such a perception inevitably results in the continuation of humans contracting and dying from the disease due to exposure to an unattended non-vaccinated canine population – the most important species globally responsible for transmission of the disease to humans.

The primary task of the animal health profession is to create an immune buffer between the animal source and humans through a rigid and sustainable vaccination strategy of the canine population. It has been proven in many countries that by maintaining vaccination coverage of at least 70% to 75% of the dog population in a country, the number of humans contracting the disease would decrease exponentially. To enable the Veterinary Services of countries to accept and fulfil this primary responsibility relative to their counterparts in the human health professions, they need to be capacitated to do so.

Capacitation of the national veterinary services of a country does not always imply only the availability of more money to control the disease. Even if such money would be re-directed for the purpose of rabies control at the animal source by the Veterinary Services, the question may well be asked if it result in an effective and coordinated effort to really control the disease. By fully accepting the core responsibilities of controlling the disease in animals and taking stock of what is really needed to achieve effective control, will the veterinary services and the veterinary profession at large, be able to claim that they have done their part to reduce and finally eliminate human cases of the disease. In the end, the success of rabies control in a country is measured by the decrease in human fatalities from the disease and not by how many dogs was or was not vaccinated. The presentation will outline some of the critical and core responsibilities and actions that need to be considered and put into operation by the veterinary service of a country to effectively control the disease and enable them, together with their human health counterparts, to deliver the assurances to the human population that rabies as a public good concern, is well and effectively attended to within the national borders of the country.
OIE ACTIVITIES TO SUPPORT SUSTAINABLE RABIES CONTROL: PVS, VACCINE BANKS AND THE OIE TWINNING

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Rabies causes an estimated 55,000 deaths worldwide in developing and in transition countries, a large proportion occurring in children. Successful rabies prevention and control requires the collective efforts of many people. Focus should be given to containment and the eventual eradication of rabies at the animal source of the disease, primarily dogs. OIE strategies emphasize addressing ‘One Health’ issues including rabies, building the capacities of veterinary services to support public and animal health, and working with a range of international and national organizations. Due recognition should be given to both immediate actions and approaches that support long term maintenance and improvements to rabies control strategies. Three examples of OIE initiatives are provided that support a sustainable approach. The PVS (Performance, Vision and Strategy) tool for the evaluation of veterinary services, PVS Gap Analysis, and PVS follow-up, aim to strengthen good governance including technical and management capacities and legislation to support continuous and ongoing improvements in these areas. Improving veterinary services including public and private components will facilitate the application of knowledge and skills to help control zoonosis such as rabies. Parenteral rabies vaccination of dogs has been the method of choice but there are limitations to this approach. Whereas oral vaccination is successfully used in certain wildlife species, it is considered worthwhile to promote research on suitable oral vaccines for dogs as well to complement parenteral vaccination and other management techniques. OIE plans to establish a Rabies Regional Vaccine Bank Pilot Program in Asia and collaborate with other partners involved in rabies control. ‘Twinning’ arrangements provide links between an OIE Collaborating Centre (the parent) and a National Centre (the candidate). These seek to improve expertise and diagnostic capacities. Current ‘twinning’ arrangements for rabies are established between the UK and China, South Africa and Nigeria, and Germany and Turkey. OIE approaches create opportunities to overcome a number of the key challenges of rabies control in a sustainable manner.
osto of Posters

Adoption of a predictive model to estimate herbivores rabies occurrence in three states of Brazil – preliminary results.

Integrated approach to rabies control

An efficient oral recombinant rabies vaccine for cats

A Model of a Sustainable Canine Rabies Prevention and Elimination Program: The Bohol Rabies Prevention and Elimination Program

The control of rabies in herbivores: particularities and challenges

A semi-quantitative method to assay the efficacy of inactivated rabies vaccine

Sustaining surveillance and comparative analysis on dog rabies immunization coverage and rabies virus isolates in some regions of China

From catch-neuter-release to catch-inject-release: immunocontraception as alternative to surgical sterilisation for free-roaming dogs

The use of immunocontraception to improve rabies eradication in urban dog populations

Evaluation of different rabies eradication strategies applied in Latvia from 1991 to 2010

Neuropathological studies of mice experimentally inoculated three bat rabies viruses isolated in Brazil

Epidemiological study of human and canine rabies in Togo: Lomé commune and Kara health regions 2001 - 2010

Pathogenesis of rabies virus (RABV) in canid and mongoose strains in South Africa

Canine adenovirus antibody levels in meso-carnivores in the United States: Implications for oral rabies vaccination

Epidemiology of rabies in Bhutan
In Brazil, herbivores rabies can be considered endemic all over the country. The main vector of rabies transmission to herbivores is the vampire bat (Desmodus rotundus), a vampire bats that can only be found between the south of North America and the tropical area of South America. Despite the decreasing number of cases, the disease still spreads in an insidious way due to: the increasing number of food sources and artificial roosts for vampire bats, disordered human occupation, and the opening of new roads and power stations, amongst others. This project aimed to create a predictive model to estimate the probability of rabies occurrence in herbivores, transmitted by vampire bats, in each municipality of three Brazilian States. The risk of virus spread was estimated using concepts of receptivity and vulnerability to the disease. Data was obtained from questionnaires sent to the Local Veterinary Units of the States of Sergipe, Rondônia and Bahia covering a number of questions related to the surveillance of rabies outbreaks in herbivores, presence of bat roosts, rabies occurrence in bats and spatial modifications. The animal density and geomorphologic features of each region were obtained from the national registries and geographic information systems. To verify the model, the risk results where compared with the 29 rabies outbreaks in 2010 distributed throughout the municipalities. Of 544 municipalities accessed, 22 (4%) were rated as having a high risk for the virus spread, 123 (22,6%) as medium risk, 189 (34,7%) as low risk, and 43 (7,9%) as negligible risk. In 167 (30,7%) cases the risk was unable to be determined because the lack of information. When the risk results were overlapped with the 29 municipalities presenting outbreaks in 2010, 14 (48.3%) cases were rated as high risk, 11 (37.9%) as medium, 2 (6.9%) as low and in 2 (6.9%) cases the risk was not determined. The results showed that the locations with outbreaks were skewed towards areas with a higher risk for the virus spread. In the future, the monitoring of risk areas could allow the targeting of efforts, adoption of control measures directed at specific locations, optimization of the field team transit, costs reduction and a better understanding of rabies spread. These preliminary results will be considered before the adoption of the methodology for the entire country. Additionally, efforts need to be made to stimulate the continuous surveillance of risk and reduce areas with lack of information.

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INTEGRATED APPROACH TO RABIES CONTROL

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Current strategies for rabies control in Europe are based on three pillars: carnivore vaccination, dog population management and information dissemination to increase public awareness on responsible dog ownership. Istituto G. Caporale has designed an integrated approach to rabies control, which includes various methods and tools.

1. Evaluation of antigenicity of a rabies inactivated vaccine on animal model
Dog use in assaying the efficacy of inactivated vaccines arises ethical and economical problems. Animal models may facilitate research on the improvement of inactivated vaccines in use. In this study, Guinea pigs were used as alternative model. A viral suspension, produced in BHK21 cells, after having successfully passed ABT and viral glycoprotein tests after inactivation, was used to produce two different vaccine preparations. In the first one the virus suspension was used without any further treatment whereas in the second one, virus purification was performed. Al(OH)₃ was used as adjuvant. The two products were inoculated into three groups of Guinea pigs, with a vaccine available on the market. Sera obtained by bleeding animals at monthly intervals, were assayed by serum neutralisation test. Serum-conversion showed differences among the three preparations.

2. Dog traceability as a tool for rabies control
Istituto G. Caporale hosts the Animal Identification and Registration System for many animal species such as cattle, small ruminants, pigs and poultry, and it was recently engaged in the development of dog and cat information and registration systems in two Italian regions. They allow lost dog tracking through links with the national database and data on dog movements. Moreover, the availability of information on the health and welfare of individual animals, is a management tool for the prevention and treatment of animal diseases. It can support epidemiologists during zoonotic disease outbreak investigation and management and for planning surveillance actions for rabies control.

3. Improving public awareness
Public awareness on rabies, together with an improved responsible dog ownership, are also key components for disease control. The CAROdog website (www.carodog.eu) - developed by Vier Pfoten International and Istituto G. Caporale, in partnership with The Federation of Veterinarians of Europe and the European Commission - was designed to promote a European wide systematic approach to canine population management, disseminating information and promoting education, identification, registration, preventive veterinary medicine and birth control. It is based on an international network of expertise and offers a number of tools also stressing the importance of stray population control to fight against rabies spreading. CAROdog offers scientific, legal, and educational tools for political strategies and concrete projects and programs, to build up a common culture of responsible dog ownership.

The Institute integrated and multitasking approach to rabies control, provides a global view of the disease situation, and represents an effective tool for its control, enabling an effective and efficient strategy for zoonotic disease control.
AN EFFICIENT ORAL RECOMBINANT RABIES VACCINE FOR CATS

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Condensed stray cats in large cities of China have drawn extensive concern about the risk of rabies epidemic if a rabid cat is introduced into the populations. Vaccination on stray cats by injection of the inactivated rabies vaccine is hard and impractical. Therefore, development of oral vaccine for cat use is necessary. A recombinant herpesvirus type I harboring the glycoprotein gene of rabies virus (RABV) was constructed by means of transposon-mediated gene transfer method. The recombinant virus was identified to have the gene incorporated into the UL2 gene of the herpesvirus genome. One milliliter ($10^5$TCID$_{50}$) of this recombinant virus was fed to 20 cats orally for 2 times, at an interval of 2 or 4 weeks. The serum samples were titrated for the appearance and the level of viral neutralizing antibodies (VNA) against rabies virus. The results showed that the recombinant virus stimulated a high level VNA in cats two weeks post inoculation, 80% of the inoculated cats seroconverted and the average antibody titer ranged from 4.5-23.38 IU/ml, two weeks after the second inoculation, all the cats seroconverted. The immunity could last for more than 6 months without apparent decline of the neutralizing antibody. Interestingly, the 10 intramuscularly inoculated cats showed only 50% seroconversion after two times of vaccination. No side effects were observed in both the orally and intramuscularly inoculated cats. These results indicated that the recombinant herpesvirus expressing the glycoprotein of RABV may serve as an efficient oral vaccine for cats, especially for the large amount of stray cats in cosmopolitan areas.
A MODEL OF A SUSTAINABLE CANINE RABIES PREVENTION AND ELIMINATION PROGRAM: THE BOHOL RABIES PREVENTION AND ELIMINATION PROGRAM

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Bohol Province was the 4th highest region for human rabies deaths in the Philippines prior to the initiation of the Bohol Rabies Prevention and Elimination Program (BRPEP). In line with the National Rabies Program goal of eliminating rabies by 2020, the BRPEP was initiated in 2007 with the goal of building a sustainable program to prevent human rabies by eliminating rabies at its source, dogs, by 2010.

The intersectoral BRPEP, managed by a council led by the Governor, integrated agriculture, public health, education, environment, legislation and local government sectors. The program included: increasing community involvement; dog population control; mass dog vaccination; improving dog bite management; veterinary quarantine; diagnostics, surveillance and monitoring. Funding came from the government, dog owners, and partner NGOs. Community volunteers facilitated the institution of the program. Dog population surveys were conducted to plan for sufficient resources for dog vaccination. Two island-wide mass vaccination and catch-up campaigns were conducted. Dog registration was implemented including a small fee that was rolled back for program sustainability. Children were educated by introducing rabies prevention modules into all elementary schools. Existing national, provincial and municipal legislation strengthened the enforcement of activities. A community awareness survey was also conducted.

Two mass vaccination campaigns conducted in 2007 and 2008 successfully registered and vaccinated 44% and 70% of the dogs. The 2009 awareness survey revealed >90% awareness of rabies and its transmission, 89% knew the BRPEP and thought it was good for their community, and 73% of the households no longer allowed their dogs to roam. Registration fees collected during the first 2 years totalled USD 105,740, approximating the annual program cost. These were re-allocated back into the community to sustain the program. Between October 2008 to November 2010, no human and animal cases were detected by the provincial surveillance system. A suspect human case and a confirmed dog case were readily detected in November 2010 and April 2011, respectively. Rapid case detection prompted the quick response and containment.

The success of the program was achieved through empowerment of the local communities and the use of the one health intersectoral approach to rabies control, through the joint efforts and shared resources of local and national government, and non-government partners. The fact that the number of human deaths has been dramatically decreased and surveillance increased indicates the program has been successful.
THE CONTROL OF RABIES IN HERBIVORES: PARTICULARITIES AND CHALLENGES

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Bovine rabies is responsible in Latin America for a mortality estimated at nearly 50,000 head of cattle and an estimated annual loss of US$ 44 million due to the indirect losses in terms of meat and milk, coupled with the devaluation of hides as a result of vampire bites. The main vector of rabies transmission to herbivores is the vampire bat (Desmodus rotundus) which is the most numerous of the three species of vampire bats that can only be found between the south of North America and the tropical area of South America. As D. rotundus is largely found in rural areas, most of Latin American rabies control programs have been structured to also perform population control of these bats. Besides having the largest commercial cattle herd of the world, Brazil has a great variety of environmental conditions that favor the maintenance of D. rotundus colonies. Since 1966, the Brazilian Ministry of Agriculture has established a program for the control of cattle and other herbivores rabies aiming to reduce disease incidence through strategic vaccination of susceptible animals, population control of vampire bats, among others prophylactic measures and surveillance activities. The present study aims to demonstrate the evolution of rabies control in herbivores and the particularities of the program in the country, for the past ten years. Despite costs and continuous efforts to control this disease, the occurrence of rabies in herbivores and in vampire bats is still endemic in Brazil and it has been notified by all states. Initiatives such as bats vaccination are still under laboratorial research, and population control of bats is extremely challenging due to the existence of abundant habitats and feed source. However, the identification of risk areas for rabies is being implemented to optimize the actions under course, and therefore to decrease the disease incidence, especially in bats, since the role of this animal as vectors of rabies virus to humans gains importance once the urban cycle is controlled.

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A SEMI-QUANTITATIVE METHOD TO ASSAY THE EFFICACY OF INACTIVATED RABIES VACCINE

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Effective vaccines and vaccination is the key factor to prevent live body from infection of rabies virus. Inactivated vaccines are one of the major types of vaccines used for dogs, cats, as well as humans. Extent of the efficacy of the vaccines, i.e., the content of virus antigen, is the only index of the inactivated vaccines. A number of methods have been established to assay the efficacy, of which the NIH method and the method developed by European pharmacopoeia are the golden ones. Here we established a method to semi-quantitatively assay the efficacy of an inactivated rabies vaccine, which uses less animals and shorter time to finish. According to the vaccine efficacy requirements, the standard rabies vaccine is, for example, diluted to 1, 2 and 3 international units per ml, and 50μl of each dilution were taken to inoculate 12 mice, respectively. The same amount of the test rabies vaccine is inoculated into 12 mice. Two weeks later, all mice were bled to collect the serum samples and the serum samples were submitted for viral neutralizing antibody assay using fluorescent antibody virus neutralization (FAVN) test or its equivalent. The 3 highest and the 3 lowest serum antibody samples of each group were removed and the average titer of the left samples was calculated. By comparing the average antibody titers of the standard vaccines with that of the test vaccine, the test vaccine efficacy can be semi-quantitatively judged.
SUSTAINING SURVEILLANCE AND COMPARATIVE ANALYSIS ON DOG RABIES IMMUNIZATION COVERAGE AND RABIES VIRUS ISOLATES IN SOME REGIONS OF CHINA

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Rabies is a preventable zoonotic disease. By compulsory vaccination of dogs, many countries and regions have controlled dog rabies and thus eliminated human rabies. However, rabies in most developing countries, especially in India and China, still remains a problem of public health. We performed a sustaining surveillance on dog rabies immunization coverage in some randomly selected regions of China from 2006-2010, using a prescribed method, the fluorescent antibody virus neutralization (FAVN), and analyzed the epidemic rabies virus isolates in these areas, aiming to demonstrate that rabies vaccination and immunization coverage in dogs is a key factor to prevent rabies virus transmission in dog populations. Our surveillance results showed that the immunization coverage has been increasing year by year in some developed cities, where the immunization coverage rate has increased from 32.6% to 78.99%; however, in less developed cities and rural areas, the immunization coverage rate is low, ranged from 7.93% to 27.97% and even none. The surveillance showed that rabies immunization coverage is highly correlated with the economy development levels of a region. At the meantime, the incidence of human rabies in regions with high rabies immunization coverage was much lower than the regions with low rabies immunization coverage, among which the incidence of human rabies in Hebei province, a developing province, showed a rapid increase in recent years, where rabies immunization coverage in rural areas has been less than 20% all through the years. The gene sequences of rabies viruses isolated from dogs in this province from 2006-2011 showed high identity with each other, and clustered into the same lineage. All this showed a direct correlation between the low percentage of rabies immunization coverage and the rapid rabies virus spreading in dog populations.
FROM CATCH-NEUTER-RELEASE TO CATCH-INJECT-RELEASE: IMMUNOCONTRACEPTION AS ALTERNATIVE TO SURGICAL STERILISATION FOR FREE-ROAMING DOGS

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Rabies elimination is targeted through dog vaccination campaigns, public education and dog population management. The latter is achieved by reducing the number of stray dogs through culling or surgical sterilisation. The aims of this study were 1. to evaluate costs and benefits of current methods used to control overabundant populations of free-roaming dogs, 2. to discuss the use of recently developed immunocontraceptives, 3. to evaluate feasibility, social acceptance and costs of managing dog populations through lethal and non-lethal methods. Culling is unlikely to be the optimal method to manage overabundant dog populations for the following reasons: (i) in most instances lethal control is carried out with little planning or monitoring of the impact on dog numbers, (ii) dogs are often killed inhumanely, (iii) dog owners might oppose culling, (iv) the use of toxicants employed to kill dogs might affect non-target species, (v) culling reinforces the “quick fix” solution and does not encourage responsible ownership. Fertility control, achieved through surgical sterilisation or contraception, could offer benign, long-term, effective and humane approaches to reducing the size and growth of dog populations. Surgical sterilisation is relatively expensive because it relies on specialised staff (veterinarians), drugs and infrastructures. There is little evidence that surgical sterilisation can adequately control dog numbers or incidence of zoonoses because too few animals are sterilised or, even when significant numbers are sterilised, the costs are unsustainable. On the other hand, the number of contraceptives developed for dogs is rapidly growing and recently developed immunocontraceptive vaccines could offer real potential to control large numbers of free-roaming dogs. The reawakened interest for contraceptives to manage wildlife is based on practical and theoretical evidence suggesting that an effective, economically sustainable reduction of free-roaming dogs can only be achieved by chemical sterilization. We present data on costs of immunocontraception versus surgical sterilisation.
THE USE OF IMMUNOCONTRACEPTION TO IMPROVE RABIES ERADICATION IN URBAN DOG POPULATIONS

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The use of fertility control to manage overabundant animal populations is increasing due to the recent development of novel immunocontraceptives that can induce infertility for several years after administration of a single dose. However, the effects of fertility control on free-roaming dog numbers are still poorly understood. This study provided evidence of the potential of fertility control to reduce the size of stray dog populations in the context of rabies control and aimed to (1) determine what proportion of dogs should be sterilised to eliminate rabies and (2) assess whether immunocontraception decreases the proportion of dogs requiring rabies vaccination. Models are usually constructed to predict the population density threshold below which rabies is predicted to die out. This threshold determines the proportion of the population that needs to be vaccinated. However, the use of an immunocontraceptive would achieve the same outcome (i.e. reduction of susceptibles) although this would take longer to attain. The models developed for this study evaluated the difference in the speed at which rabies is eliminated, and how well the population is maintained below this threshold to prevent re-emergence. The results suggested that immunocontraception combined with rabies vaccination has the potential to eliminate rabies in urban dog populations. In particular, the addition of fertility control will decrease the proportion of dogs that require rabies vaccination. The results are discussed in terms of benefits obtained from combined vaccination and sterilisation. More complex spatial models could be tailored to specific urban areas to account for differential accessibility of dogs. This model represents the next step towards an integrated approach to rabies management in urban dog populations.
EVALUATION OF DIFFERENT RABIES ERADICATION STRATEGIES APPLIED IN LATVIA FROM 1991 TO 2010

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Rabies is endemic in Latvia since the 19th Century with fox-mediated rabies having been the main problem for the past two decades. Between 1991 and 2010, there were a total of 5897 rabies cases in various animal species (78% in wildlife) including three human rabies cases. Annual prophylactic vaccination of dogs and cats against rabies is compulsory.

The aim and objective of the study was to evaluate the impact of different implemented oral rabies vaccination (ORV) strategies in e.g., red foxes (Vulpes vulpes) and raccoon dogs (Nyctereutes procyonoides) on the rabies incidence in Latvia between 1991 and 2010.

Between 1991 and 2010, depending on financial resources the Food and Veterinary Service applied different ORV strategies which can be categorised as follows:
1. Patchwork vaccination (1991-1997). Vaccine baits without biomarker (N=28,000) were manually distributed (average bait density – 4 baits/km2) in regions with the highest rabies incidence.
2. Small-scale vaccination (1998-2004). Manufactured vaccine baits (N=1,106,000) containing tetracycline as a biomarker were manually distributed (average bait density – 11 baits/km2) in a limited regions of the country. Monitoring of ORV campaigns focussed on determination of uptake only.
3. Large-scale vaccination (2005-2010). The entire territory of Latvia was covered with manufactured baits (N=14,414,000) using aerial distribution (average bait density – 25 baits/km2). Monitoring of ORV campaigns included determination of herd immunity in hunted target animals.

The efficacy of the three ORV strategies (1-3) on the rabies incidence after implementation was analysed and compared.

An epidemiological analysis revealed that ORV strategies 1 and 2 did not have a significant effect on the rabies incidence. Despite an increase in the number of vaccine baits used in strategy 2, rabies incidence increased resulting in a peak in 2003 (963 cases). Only strategy 3 resulted in a drastic decrease of the rabies incidence; within a short period of time rabies cases went down from 421 in 2005 to 16 in 2010.

Rabies has been a serious problem also in Latvia neighbouring countries – Lithuania, Estonia, Russian Federation and Belarus. Depending on a country, different ORV strategies have been applied during last decades but the best results are achieved by large-scale vaccination. However it should be taken into consideration that implementation of large-scale vaccination requires large financing and strict organization.

Conclusions:
If wildlife rabies is endemic throughout the country Patchwork and small scale vaccination (ORV strategies 1 and 2) are ineffective and does not result decrease of rabies incidence. Only large-scale vaccination (ORV strategy 3) can be considered cost-effective and will take less time to eliminate rabies provided international recommendations are followed.
NEUROPATHOLOGICAL STUDIES OF MICE EXPERIMENTALLY INOCULATED THREE BAT RABIES VIRUSES ISOLATED IN BRAZIL

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Rabies is still endemic in many parts of the world. Rabies virus is a highly neurotropic and develops fatal encephalomyelitis in humans and animals. In the New World, bats maintain the circulation of different lineages of the rabies virus (RABV). The peculiar properties of the RABV variants circulating among vampire bats was reported that paralytic clinical feature in not only bats but also cattle and humans and virtually never furious. In this study, the mice inoculated intramuscularly or intracerebrally three bat RABVs isolated from cattle (P17 virus) and sheep (P18 virus) that spilled over from hematophagous bat (Desmodus rotundus), and the RABV (MP virus) isolated from insectivorous bat (Molossus molossus) were examined immuno- and histo-pathologically. Although viral antigens were widely distributed in central nerve system (CNS) and peripheral nerve system (PNS) with varying degrees of non-suppurative encephalomyelitis, the recruit of inflammatory cells (lymphocytes) was not prominent. And apoptosis of neural cells was observed in the CNS of mice infected with MP virus but not P17 and P18 viruses. Mice inoculated with P18 virus but not P17 and MP viruses frequently showed Negri body in the CNS including spinal ganglions, medulla oblongata, mid brain, hippocampus and cerebral cortex. Negri body was not observed in the PNS of mouse skull by the light microscopy, but viral antigen was detected in not only salivary gland (acini of the submandibular gland, minor salivary gland) but also olfactory epithelium, taste bud and neural layer of the eyeball. Those findings were not observed in mice inoculated CVS strain, comparatively. Delpietro HA and et al. (2001) reported that the paralytic rabies virus belonged to vampire-bat variants infected to cattle was isolated from 4.6% of salivary glands and from 1.6% of saliva samples, however the rest of the peripheral tissues were negative. The further analysis of CNS and PNS in mice inoculated with the street bat viruses would give us the neuropathological feature of street bat virus with the comparison of the fixed virus (CVS strain).
EPIDEMIOLOGICAL STUDY OF HUMAN AND CANINE RABIES IN TOGO: LOMÉ COMMUNE AND KARA HEALTH REGIONS 2001 - 2010

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The objective was to clarify the epidemiologic situation of rabies in Togo to strengthen monitoring activities in public and animal health.

A retrospective study was conducted in Lomé commune (LC) and Region Kara (RK) on 1284 patient records in health facilities (FS) after exposure and suspected human rabies; on records of quarantine of biting dogs in Veterinary Services (SV) from 2001 to 2010; a cluster study on 40 households to determinate ratios.

Of the 1284 dog bites and deaths cases reported, 696 were male, 510 female, for 78 there was no information. The difference between the two sexes is statistically significant p <0.00001. People bitten at the age of 1-15 years represented 53.15% (CI= 50.4- 55.6%) and were most referred to the FS. The difference between frequencies of bites and rabies deaths in LC and RK was not statistically significant $X^2 = 1.65$ p = 0.68 after standardization. The difference in incidence of human rabies observed in LC and RK (0 and 39 ) was not significant: $X^2= 3$, $25.10^4$ p <10^-12. The rabies incidence of the dog population in LC was smaller than in RK: $X^2=3.9$ $10^3$ p <10^-12. Beyond 5 days 39% (CI= 32.9-45.1%) (LC) and 10% (CI= 6.3-13.7%) (RK), presented in the SV. The ratio of dogs/household in urban areas was 0.9, and 2.1 in rural areas, the ratio of man/dog was 6 / 1 and 7 / 1, respectively.

The rabies incidence was higher in the two regions; people between the age of 1-15 years were more concerned. People may be sensitized about the necessity to immunized dogs and stay away from dogs to better control the disease or implemented post exposure prophylaxis. Monitoring should be strengthened, vaccination campaigns organized to control dog rabies in Togo.
PATHOGENESIS OF RABIES VIRUS (RABV) IN CANID AND MONGOOSE STRAINS IN SOUTH AFRICA

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Rabies is one of the oldest zoonotic diseases in medical history. It is still an important public and veterinary health threat since it is constantly diagnosed in domestic and wild carnivore species world-wide. According to WHO, 55,000 human deaths happen annually, although post-exposure management is in place. Presently, there are two RABV biotypes circulating in South Africa – the canid and mongoose rabies strains. These biotypes are independently maintained but are also capable of jumping species boundaries (i.e. infectious “spillover”, mongoose rabies strain recovered in dogs). This study was undertaken in order to give a new insight on pathogenicity of three South African RABV strain prototypes (canid, mongoose and spillover).

The sequences of complete glycoprotein genes of the three strains were established. Mongoose and spillover strains showed 4.8% divergence at the nucleotide level. The homology was respectively 85.96% and 87.02% between canid/mongoose strains and canid/spill over strains. It has been demonstrated that certain amino acids on the extracellular domain of the glycoprotein are key factors for viral pathogenesis. The amino acids at positions at N-194, F-318, H-352 and R-333 which are known as pathogenic determinants in RABV exhibited the same amino acids amongst three South African RABVs and fixed laboratory strains (CVS and ERA). Therefore, other determinants involved in the pathogenesis have been looked for.

A recent study (Préhaud C. et al, 2010) showed that the PDZ-binding site (PDZ-BS) located at the carboxyl terminus of the glycoprotein is a key element influencing RABV pathogenesis by controlling the RABV neuroprotective or neuronal death phenotypes. Chimeric G proteins were constructed by grafting the last 13 amino acids of the South African RABV glycoproteins in place of the 13 amino acid residues of G CVS NIV strain. These chimeric proteins were expressed in recombinant lentiviruses and the neurites outgrowth or apoptotic properties were evaluated. The specific phenotypes and the consequence it might have in terms of pathogenicity will be presented and discussed.
CANINE ADENOVIRUS ANTIBODY LEVELS IN MESO-CARNIVORES IN THE UNITED STATES: IMPLICATIONS FOR ORAL RABIES VACCINATION

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The recombinant canine adenovirus (serotype 2)-rabies glycoprotein vaccine (CAV2-RG) has demonstrated efficacy in protecting against rabies in striped skunks and raccoons in captivity. In addition, the vector for this recombinant does not pose potential public health concerns associated with other recombinant oral rabies vaccines currently in use in North America. In pursuing CAV2-RG as a prospective candidate for field testing, we conducted sero-surveys representing a diverse range of meso-carnivore rabies reservoirs in North America. Antibody levels were lowest in the raccoon (Procyon lotor) (mean 2.5%, n = 696, multiple states and years) and highest in the coyote (Canis latrans) (72.4%, n = 58, TX 2009); the striped skunk (Mephitis mephitis) and gray fox (Urocyon cinereoargenteus) had identical intermediate CAV2 antibody levels at 22 percent. Small Asian mongoose (Herpestes javanicus) sera from Hawaii are being analyzed. These findings suggest that meso-carnivores more phylogenetically distant from canids would likely respond more favorably to field application to CAV2-RG presented in a proper bait formulation. However, CAV2-RG would not likely be adequate to conduct effective oral rabies vaccination campaigns targeting all meso-carnivore rabies reservoirs in North America, irrespective of bait formulation. This limitation along with the current economic climate and other limiting factors underscore the need for access to a single safe, inexpensive oral rabies vaccine in the United States that is most efficacious in all meso-carnivores.
EPIDEMIOLOGY OF RABIES IN BHUTAN

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Canine rabies was prevalent throughout Bhutan until the early 1990s but has been controlled and eliminated throughout much of Bhutan by stray dog control and vaccination programs. Currently, rabies is endemic only in southern parts of Bhutan that border India, with occasional re-emergence in previously free areas. Sporadic human rabies deaths (~0.28/100,000/year) are also reported from south Bhutan (1). Presence of rabies in south Bhutan results in substantial cost to society and the government in the form of prevention and control program costs, post exposure prophylaxis cost in humans and deaths of farm animals. Nation-wide dog population management (capture-neuter-vaccinate-release) and a rabies elimination project is ongoing. The goal is to cover more than 75% of the total dog population. Here we describe the rabies situation and risk areas for the surveillance and control program in Bhutan.

Descriptive statistics and GIS-based analysis were performed to understand the pattern and to visualize the spatio–temporal distribution of rabies in animals in Bhutan.

The majority of the cases were reported in cattle (55%, 447/814) and dogs (39%, 317/814), with only a few cases in other species (horses 17/814; cats 14/814; pigs 13/814; and goats 6/814). The pattern of reported rabies cases was stable until 2005, but increased in 2006 and 2008 due to major outbreaks in eastern and southwest Bhutan (2). Eleven of the 20 districts and 59 of the 205 sub-districts in Bhutan reported rabies between 1996 and 2009, but reports were more common in areas of southern Bhutan that share a border with India. Significant clusters of cases were observed in south central and southwest Bhutan. This suggests that rabies endemicity has been maintained in a stray dog population in southern border areas, or that this endemicity could be the result of trans-border movement of infected stray dogs. Phylogenetic studies suggest that the rabies virus strain circulating in southern Bhutan is closely related to Indian rabies virus strains (3). We recommend that the rabies control program should be focussed in the highly endemic areas of southern Bhutan. Vaccination of dogs in these areas would create an immune buffer and eventually eliminate the main source of rabies virus in the country.

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