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Type A

(8 RNA segments)
9 Kb
(polimerasis complex)
(PB1, PB2, PA) (Efficient growth)
4° - HA (Haemoagglutinin) (Infectivity)
5° - NP (Nucleoprotein)
6° - NA (Neuroaminidase)
7° - M1, M2 (MatrixProt.)
8° - NS.1, NS.2 (Pathogenicity)

Type A Mammals and Birds (At the time, 16 HA and 9 NA are known)

Type B Human
Type C Human
Dhori/Thogoto (Tick borne)

Mammals
Macro Evolution
RNA virus exhibit the highest mutation rate of any group of organism one per genome per replication (around $10^{-3} / 10^{-5}$)

Micro Evolution

Refresh genes Time = Reproductive cycle / Mutation rate
Human mutation of single gene (1000 bases) might take thousands of generations

Antigenic drift / Shift Recombination

Population size
$10^{12}$ viral particles in an organism

Population growth
one virus can produce 100,000 viral copies in 10 hours
During flu A coinfection in swine, the genetic reassortment between birds and mammals viruses is possible.
Un master di metamorfosi
Variabilità antigenica

Virus Influenzali

Tipo A, B
epidemico

Tipo A
pandemico

Antigenic Drift

Antigenic Shift

(HA)

(NA)
Mutazioni casuali

Flu A & Flu B: antigenic drift

cambiano HA/NA
Sequenza di aminoacidi basici (R / K ) nel sito di clivaggio dell’emoaglutinina (HA0 - HA1/HA2)

**LPAI**
Proteasi localizzate negli organi respiratori e nell’intestino

**HPAI**
Proteasi ubiquitarie (*Furina like*)
Influenza A: **antigenic shift**

Modello 1

**Flu A Aviaria**  
**Flu A Umana**

*riassortimento*

Modello 2

**Flu A Aviaria**

*Salto di specie*

**UOMO**
antigenic shift

MODELLO 1: riassortimento

Virus dell’influenza aviario

Virus dell’influenza umano

MIXING VESSEL
Recettori α2,3 α2,6

Virus riassortante
antigenic shift

MODELLO 2: salto di specie

Salto di specie

Virus dell’influenza aviario

UOMO

Virus dell’influenza umano
Biogenesi di ceppi pandemici

*match* HA-NA

**SET GENICI ISOLATI IN NATURA:**

**UOMO:** H1H1, H2N2, H3N2,

**SUINO:** H3N2, H1H1
Biogenesi di ceppi pandemici

Capacità replicativa

Complesso polimerasico: PB1, PB2, PA

Virus umano

Efficienza di replicazione

Virus aviaro

Virus riassortante

Specificità d’ospite
<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
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<tr>
<td>1918</td>
<td>(Spanish Flu)</td>
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<td>1968</td>
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<td>1977</td>
<td>(The USA)</td>
<td>H1N1</td>
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Dal 1977 H3N2 e H1N1 co-circolano
The 1918 flu virus is resurrected

JK Taubenberger
Nature 6 ottobre 2005

Caratterizzazione molecolare dei geni di PA-PB1-PB2

È un virus “avian-like”

differiscono solo di pochi aminoacidi dalle sequenze consensus aviarie:

7 PB1
7 PA
5 PB2

aa 627

Importante per l’adattamento alle cellule di mammifero

Alta virulenza:

differenza di 10 aa per il complesso polimerasico tra virus aviari e umani

H1N1
H5N1
H7N7

Codon codificanti il peptide F2 di PB1 (induzione della morte cellulare)
Pandemie
Influenzali: Passate e Future?
L’influenza mette le ali
### Infezioni umane da virus aviari

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<tr>
<th>Anno</th>
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<td>Oct 2005</td>
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*(118 casi, 61 morti)*
Reservoir: Why Ducks?
Species where the virus can replicate and maintain itself indefinitely in the time

Water related species

Migratory behaviour

Cyclic Interaction between populations coming from different areas

Intestinal virus replication

Virus shedding by means of faeces (from 2 to 4 weeks)
The Duck populations wintering in Western Palearctic ranges between 13 and 15 million of birds.

The Mallard duck has an European population near 5 million of birds, 75000/100,000 of these are wintering in Italy.
The Teal winters in Mediterranean areas with 2,5 million of birds (51,000 in Italy)
The Wigeon winters in the same region with 1,5 million (71,000 in Italy).
The Pintail has 1,3 million of birds (200,000 winter in the Mediterranean areas).
The Shoveler European population consists of 1 million of birds, 100,000 of these winter in Mediterranean areas and 20,000 in Italy.
The Pochard winters in the Mediterranean areas with 750,000 birds (43,000 in Italy).
The Tufted duck winters in Italy with 8,500 birds.
Duck migrations in Europe from N/E to S/W

Moult migration areas: Aggregation of many different ducks and viruses populations (during May, June, July)

Post-reproductive - first step - May, June Moult migration

Wintering migrations - second step - from August to October

Wintering areas

Wintering areas

Reproductive areas
Endemic Subtypes e.g. HA1
Summer / Autumn Period
(Population with immunity)

Viral Pressure Amplification

Ducks population Structure

Adults 50%
Young Ducks 50%
"New Subtypes"
Population without immunity

*e.g.* H7

(Italy, 2001)
Epiphenomenon species:
Host species where the virus can spread and replicate
but in this species the virus is not able to maintain itself indefinitely in the time

H5N3  HPAI

LPAI

[Italy (H10N8) 1977; Italy (H7N2) 1994, and many others..]
Epiphenomenon role during migration

- flock size
- migratory in long/short distance
- time necessary to migrate
- migration routes and stages
Intensively reared Domestic reservoir

Wild reservoir

Environment

Domestic reservoir

The Ecological interfaces

Wild interfaces

Intensively reared
The chicken’s role (strains LPAI/HPAI)

HPAI H5/H7

Epifenomena

Environmental factors and immunity

Reservoir

threshold
The host (duck) and the virus have developed a coevolution, in this condition the virus live an evolutionary freezing.

With low frequency of viral changes

(Convergent evolution)

Viral population
Non adapted host - The Comet Theory

(Divergent Evolution)
The Comet Theory
Divergent Evolution

Molecular mimicry

why?

Many viral variants

Viral population mean

Many viral variants

High frequency of viral changes
host and virus without coevolution
host with high population turn over
During Poultry infection, the possible evolution from LPAI to HPAI may occur

HPAI usually *kill the domestic and wild reservoirs only in the first outbreak period*;

HPAI *kills domestic non reservoir birds* (i.e. chickens, Turkeys) and *some wild epiphenomenon species*.

*subsequently* the virus could reduce its *patogenicity for the reservoir* and the spread of the infection by *migrations* might be possible.
Structure of the cleavage site and pathogenicity

Infectivity

Uncoating

The host spectrum

Attachment

Proteolytic activation

Amino acid 627 in PB2 and efficient growth

Efficient growth
**Tabelle di sensibilità e specie colpite: interpretazione del ruolo**

- *spill over*

- **fattori di presenza:** presenza incostante o meno sul territorio

- **momento biologico delle specie** (- + giovani sensibili)

- **assenza di informazioni sullo stato immunitario della popolazione**
### Order: Anseriformes

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<thead>
<tr>
<th>Species</th>
<th>Common Name</th>
<th>Threat Level</th>
<th>Status</th>
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<td>Black swan</td>
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<td>Cygnus cygnus</td>
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<td>+</td>
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<td>C. melanocoryphus</td>
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<td>Mute swan</td>
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<td>Update on Avian Influenza #35</td>
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<td>Dendrocygna viduata</td>
<td>White-faced whistling-duck</td>
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<td>Branta sandvicensis</td>
<td>Hawaiian goose</td>
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<td>Netta peposaca</td>
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<td>Columba livia</td>
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<td>Streptopelia tranquebarica</td>
<td>Red-collared dove</td>
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<td>Spizaetus nipalensis</td>
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<td>van Borm et.al., 2005</td>
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<td>Hill mynah</td>
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<td>Eurasian tree-sparrow</td>
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<td>Korean magpie</td>
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**Order: Passeriformes**
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<td><em>Phoenicopterus ruber</em></td>
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<td><em>Strix uralensis</em></td>
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PROBLEMI NEL TROVARE GLI ANIMALI MALATI

Gli animali malati e morti sono rapidamente rimossi dai predatori e dagli scavenger, e perciò non disponibili per le indagini.

Come quantificare i casi?

Soggetti ammalati: entità dei sintomi “collaborazione” della specie mezzi diagnostici “abilità” del veterinario nel Trovare gli animali

Ricerche di carcasse: marcatura delle carcasse

Anatidi 0% (0/50)
12% (6/50)

Taglia Anatidi Passeriformi

Eccezioni costituite da alcune epidemie
FACTORS CODITIONING THE VIRAL SPREAD

- Incubation period
- Virus shedding
- Age of the bird
- Persistence of the virus in the environment
- Dimension of the flock
- Migration activities
- Congregation factors
- Season
- Others

WITH PROTECTIVE POPULATION IMMUNITY:
- Low virus replication in adults
- High virus replication in youngs

WITHOUT PROTECTIVE POPULATION IMMUNITY:
- High virus replication in all age classes of birds

WITH PARTIAL OR CROSS PROTECTIVE POPULATION IMMUNITY:
- Birds may became sick, do not die and may spread the infection

WITHOUT PROTECTIVE POPULATION IMMUNITY:
- Birds became infected and can die quickly (LPAI H5N1)
- Birds became infected do not die and may spread the infection

In Late 2002 an outbreak of HPAI H5N1 cause dead among resident waterfowl and wild migratory birds in two Hong Kong nature parks. (Sturm, Ramirez et al. 2003)
STUDY AREA
ORBETELLO LAGOON
TUSCANY - ITALY

VIROLOGICAL AND SEROLOGICAL INFLUENZA SURVEILLANCE SYSTEM
(ISS - OMS National Influenza Center)
AMONG WILD WATERFOWL, SINCE 1992
Monitoring the lagoon with sentinel ducks
Research in the reservoir species:

- Fecal dropping
- Duck trapping
- cloacal swabs
- Blood sampling
- Ringing
WATERFOWL RINGED IN THE STUDY AREA AND RECAPTURED IN SEVERAL EUROPEAN SITES
Flyways and movements

- East Asia Australian Flyway
- Central Asia Flyway
- Black Sea Mediterranean Flyway
- East Asia Australian Flyway
1 - Mallard duck
2 - Other dabbling Duck
3 - diving Duck
4 - Coots
Results:
During all years, strong relations are shown in the seroprevalence of the duck groups.

Seroprevalences are higher in adults than young Coots
No differences related to the age were shown in ducks
SEROLOGICAL PERCENTAGE OF COOTS (Fulica atra) FOUND SEROPOSITIVE TO SUBTYPES OF INFLUENZA VIRUSES (1992-1998)
VALUES CALCULATED ON 24 COOTS NP-ELISA POSITIVE

ANTIGENS: 14 REFERENCE STRAINS OF INFLUENZA VIRUSES HAVE BEEN USED (FROM H1 TO H14); 4 VIRUS (H1*, H3*, H5*, H10*) WAS ISOLATED FROM WINTERING WATERFOWL; 1 STRAIN WAS ISOLATED FROM TURKEY: A/TURKEY/ITALY/6423-1/99 (H7N1)

H5N1 19/09/2005
Mirandola (MO)
ANNUAL DISTRIBUTION OF NA INFLUENZA SUBTYPES ISOLATED FROM 2524 FERAL DUCKS AND 582 COOTS IN ITALY (1993-2003)
**VIRUS ISOLATION PREVALENCE % IN CAPTURED DUCKS**

- Mallard (N. 436)
- Other dabbling ducks (N. 50)
- Diving ducks (N. 106)

**SEROCONVERSION % IN RECAPTURED DUCKS**

- Mallard (N. 39)
- Other dabbling ducks (N. 9)
- Diving ducks (N. 3)

Nov. 1993 / Jan. 1999
Interspecies transmission of an H7N3 influenza virus from wild birds to intensively reared domestic poultry in Italy

Laura Campitelli, a,⁎ Elvira Mogavero, a Maria Alessandra De Marco, b
Mauro Delegn, a Simona Puzelli, a Fabiola Frezza, a Marzia Facchini, a
Chiara Chiapponi, d Emmanuela Foni, a Paolo Cordioli, a Richard Webby, f
Giuseppe Barigazzi, d Robert G. Webster, f and Isabella Donatelli a

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October 2001

H7N3 FIRST ANCESTOR

October 2002

Type A
(8 RNA segments)
-PB1, PB2, PB3-
-PA-

4° - HA (Haemagglutinin)
5° - NP (Nucleoprotein)
6° - NA (Neurominidase)
7° - M1, M2 (MatrixProt.)
8° - NS .1, NS 2

Virus analyzed in this study

<table>
<thead>
<tr>
<th>Virus</th>
<th>Subtype</th>
<th>Date of isolation</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>A/Mallard/Italy/35/99</td>
<td>H2N3</td>
<td>December 1999</td>
<td>Tuscany</td>
</tr>
<tr>
<td>A/Mallard/Italy/16/99</td>
<td>H2N3</td>
<td>December 1999</td>
<td>Tuscany</td>
</tr>
<tr>
<td>A/Mallard/Italy/208/00</td>
<td>H5N3</td>
<td>August 2000</td>
<td>Tuscany</td>
</tr>
<tr>
<td>A/Mallard/Italy/33/01</td>
<td>H7N3</td>
<td>October 2001</td>
<td>Tuscany</td>
</tr>
<tr>
<td>A/Mallard/Italy/43/01</td>
<td>H7N3</td>
<td>October 2001</td>
<td>Tuscany</td>
</tr>
<tr>
<td>A/Turkey/Italy/2148/02</td>
<td>H7N3</td>
<td>October 2002</td>
<td>Lombardia</td>
</tr>
<tr>
<td>A/Turkey/Italy/220158/02</td>
<td>H7N3</td>
<td>October 2002</td>
<td>Lombardia</td>
</tr>
</tbody>
</table>

Note. All isolates were obtained from cloacal swabs. None of the animals from which the isolates were obtained showed any disease signs at the time of sample collection. However, 2 weeks before collection, the two birds that were the sources of A/Turkey/Italy/2148/02 and A/Turkey/Italy/220158/02 had shown mild respiratory symptoms, which were diagnosed and treated as mycoplasmosis.
<table>
<thead>
<tr>
<th>Species</th>
<th>NA Stalk Region</th>
<th>Amino Acid Residues</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tern/Astr/775/83</td>
<td>H13</td>
<td>AFNAVHIGKVEKKSTTTTPTVPVYNCSITVTITKHTTINNITTVFQDETHFPL</td>
</tr>
<tr>
<td>Mallard/It/208/00</td>
<td>H5</td>
<td>IFNTVIHEKICDHQTVVYTPITAPPVPVCNCSITITYYNTVNNITTTITIKAEKHFKSSL</td>
</tr>
<tr>
<td>Mallard/It/35/00</td>
<td>H2</td>
<td>IFNTVIHEKIDHGQTYYPTIAAPVSNCSDTITIYNTVNNITITTITIKAEKHFKSSL</td>
</tr>
<tr>
<td>Mallard/It/36/00</td>
<td>H2</td>
<td>IFNTVIHEKIDHGQTYYPTIAAPVSNCSDTITIYNTVNNITITTITIKAEKHFKSSL</td>
</tr>
<tr>
<td>Mallard/It/33/01</td>
<td>H7</td>
<td>IFNTVIHEKIDHGQTYYPTVAPVSNCSDTITIYNTVNNITITTITIKAEKHFKSSL</td>
</tr>
<tr>
<td>Mallard/It/43/01</td>
<td>H7</td>
<td>IFNTVIHEKIDHGQTYYPTVAPVSNCSDTITIYNTVNNITITTITIKAEKHFKSSL</td>
</tr>
<tr>
<td>Turkey/It/214845/02</td>
<td>H7</td>
<td>IFNTVIHEKIDHGQTYYPTAPVV .................................. TKAEPFKSSL</td>
</tr>
<tr>
<td>Turkey/It/220158/02</td>
<td>H7</td>
<td>IFNTVIHEKIDHGQTYYPTAPVV .................................. TKAEPFKSSL</td>
</tr>
<tr>
<td>Pigeon/Nan/9-366/00</td>
<td>H3</td>
<td>IFNAVHEKIDGQTVIYPTITPVPVCNCSDTITIYNTVNNITTTITIKAEKHFKSSL</td>
</tr>
<tr>
<td>Bantam/Nan/9-058/00</td>
<td>H3</td>
<td>IFNAVHEKIDGQTVIYPTITPVPVCNCSDTITIYNTVNNITTTITIKAEKHFKSSL</td>
</tr>
<tr>
<td>Duck/Ger/1215/73</td>
<td>H2</td>
<td>IFNTVIHEKIDHGSTTVYPTITTPVPVCNCSDTITIYNTVNNITTTITITEAERHFKPSL</td>
</tr>
<tr>
<td>Turkey/Min/916/80</td>
<td>H7</td>
<td>VFNTVIHEKIDGHSVTVIHPITMPAIVPCNCSDTITIYNTVNNITTTITITEAERLFKPLL</td>
</tr>
<tr>
<td>RuddyTurnstone/NJ/65/85</td>
<td>H7</td>
<td>IFNTVIHEKIDGQTVIYHTPIIPAVSNCSDTITIYNTVNNITTTITITEAERPFKPLL</td>
</tr>
</tbody>
</table>

Fig. 2. Alignment of the NA stalk region of N3 viruses. The full names of virus strains are as indicated in Fig. 4. Potential glycosylation sites are underlined. Asterisks indicate conserved amino acid residues.
Serological Analysis of Serum Samples from Humans Exposed to Avian H7 Influenza Viruses in Italy between 1999 and 2003

Simona Puzelli,1 Livia Di Trani,2 Concetta Fabiani,1 Laura Campitelli,1 Maria Alessandra De Marco,3 Ilaria Capua,4 Jean Francois Aguilera,5 Maria Zambon,5 and Isabella Donatelli 1

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2 Department of Food and Animal Health, Istituto Superiore di Sanità®, Rome,
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4 Istituto Zooprofilattico Sperimentale delle Venezie, Legnaro, Padova, Italy;
5 Centre for Infection, Health Protection Agency, London, United Kingdom

References
Ducks / Sea Gulls

These species have frequently interactions

- Mallard
- Wigeon
- Teal
- Herring gull
- Shoveler
- Pintail
- Black headed gull
- Herring gull

Sternidae Laridae

DELTA PO NATIONAL PARK
<table>
<thead>
<tr>
<th>Species</th>
<th>N° examined</th>
<th>N° Positives</th>
<th>Prevalence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common Tern</td>
<td>41</td>
<td>1</td>
<td>2,4</td>
</tr>
<tr>
<td>Little Tern</td>
<td>13</td>
<td>1</td>
<td>7,7</td>
</tr>
<tr>
<td>Sandwich Tern</td>
<td>71</td>
<td>1</td>
<td>1,4</td>
</tr>
<tr>
<td>Black Tern</td>
<td>15</td>
<td>2</td>
<td>13,3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>140</strong></td>
<td><strong>5</strong></td>
<td><strong>3,6</strong></td>
</tr>
</tbody>
</table>

*(All HI negatives for H5 and H7)*

**Sternidae**

Emilia Romagna Region  
2001, Italy  
Type A seroprevalence
**Laridae**

Emilia Romagna Region, 2001
Italy, Type A seroprevalence

*One adult of Herring Gull was H7 seropositive*
Virological exams
(Italy)
Herring Gull
(Juveniles)
Emilia Romagna Region

in 1999: 64 samples
in 2000: 70 samples
All negatives to Avian influenza virus

Nestling of Herring Gull
Passeriformes
Sampled in Italian wetlands


Passer montanus
Acrocephalus scirpaceus

All cloacal swabs result negative to Avian influenza virus.
Most evidence of the monophyly of Galloanserae come from molecular studies, and the group is not well supported by morphological grounds. However, the most recent, although preliminary, phylogenetic analysis of modern birds based on morphology (Livezey & Zusi, 2001, Meyr & Clarke, 2003) seem to confirm the monophyly of Galloanserae.
Galliformes
( Sedentary land based birds)
February/March 1992/93/94
Samples size:
394 Pheasants
( Phasianus colchicus torquatus)
trapped in the wild
30 Coming from reared groups
All sera were found negatives to type A Influenza viruses

Si presentano percentuali di sieri di anatidi IP-positivi testati in HI nei confronti di alcuni cepi H5 e H7 per l'anno 2001-2002.

Per l'anno 2001, le percentuali di sieri HI-positivi sono state:
- **germano (n. 164)**: 5%
- **volpoca (n. 6)**: 3%

Per l'anno 2002, le percentuali di sieri HI-positivi sono state:
- **germano (n. 168)**: 7%
- **volpoca (n. 3)**: 2%
Owls

- 114 Owls

All sera were negative to type A Influenza virus

Birds of prey

- 33 Birds of Prey

- (Falcons and others)

1 Buzzard and 1 Peregrine Falcon were positive to type A Influenza virus

Trans-saharians migratory duck (Anas querquedula) 126
Garganeys

Trapped in Italian Wetlands in March 1998
126 Cloacal Swabs were negatives
for type A Influenza virus
seroprevalence (type A) = 9.6%
All sampled ducks were negative for the H7 subtype

Galliformes
(Migratory land based birds)
Samples size: 258
Quails
(Coturnix coturnix c.)

Trapped in Italy during May 1998
All sera were found negatives to type A Influenza viruses

Transaharian migratory birds:
The Ethiopian Region
Garganeys and Quails

Samples size: 258
Focolai e Censimenti aerei....
Ministero della salute: Ordinanza del 11/02/2006

**MISURE URGENTI DI PROTEZIONE PER CASI DI INFLUENZA AVIARIA AD ALTA PATOGENICITÀ NEGLI UCCELLI SELVATICI**

**ZONA DI PROTEZIONE:**

ABBATTIMENTO E DISTRUZIONE DEGLI ANIMALI SENSIBILI INFETTI, SOSPETTI DI INFEZIONE E DI CONTAMINAZIONE

ne trovate qualcuno in questa immagine?
Circolare del Dipartimento della Sanità pubblica vet. 15 Febbraio 2006
Agonizzanti...ovvero Stato preagonico
autorizzato dai Serv. Vet. Locali senza il rispetto della precedente
procedura...ma con

Ordinanza del Sindaco su parere favorevole dei Serv. Vet. Locali sentite
le unità di crisi regionali e locali
Why to kill?
The Anas castanea example
Risk Areas? Theoretical.....

Out breeding and wandering birds

Unpredictable

-40°C
-20°C
Avian Influenza Surveillance Program (Wild)

Why (monitoring wild birds)? and Why not? (Sentinel ducks, Fecal dropping)
when, why

Environmental viruses
## Viral resistance:

(From Stallknecht, 1999/2006)

<table>
<thead>
<tr>
<th>Water Type</th>
<th>Survival Times</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Drinking water</strong></td>
<td></td>
</tr>
<tr>
<td>- 4 days at 22°C</td>
<td></td>
</tr>
<tr>
<td>- 30 days at 0°C</td>
<td></td>
</tr>
<tr>
<td><strong>Distilled Water</strong></td>
<td></td>
</tr>
<tr>
<td>- 102 days at 28°C</td>
<td></td>
</tr>
<tr>
<td>- 207 days at 17°C</td>
<td></td>
</tr>
<tr>
<td><strong>Experimental conditions</strong></td>
<td></td>
</tr>
<tr>
<td>- 9 days at 28°C</td>
<td></td>
</tr>
<tr>
<td>- 100 days at 17°C</td>
<td></td>
</tr>
</tbody>
</table>

*Max infectivity:
salt water with PH 6.2
water without salt PH 8.2*
Decoys

Hunters

dogs

Hunter’s and health risk

Hunted birds
Wild ducks 7.5 mil. susceptible/year
In all the Palearctic (50,000 in Italy)

Aquatic birds 23.5 mil.
(230 species In all the Palearctic)

Potential Domestic Reservoir:
9.2 mil. (7 million of raised Ducks) /year.
90% of these ducks are reared in the
Lombardia and Veneto Italian Regions.

Domestic Epiphenomena: 4 Billion
Susceptible host/year in Europe,
over 560 million/year in Italy
Dispersione della popolazione avicola

65% della produzione avicola nazionale

3.300 allevamenti avicoli
95 milioni di volatili accasabili/ciclo

65% della produzione avicola nazionale
Aree ad alta densità avicola in Europa

Olanda (Geldersvalley)
20-25 allevamenti/km²

Spatial distribution of poultry farms in Veneto Region (Italy)

Poultry farm

12 allevamenti/km² (provincia di Verona)

Olanda (Geldersvalley)
20-25 allevamenti
The South East Asian melting pot
Protein sources
substratum
Protein sources
substratum
Protein sources
substratum
The evolutive acceleration
The Research Group

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WWF Italia (M. Carsughi, A. Canu, L. Calchetti,) Italy

R.G. Webster (St. Jude Children’s Research Hospital, Memphis, Tennessee, USA)