WORKSHOP NOTES

The 2nd International Workshop on Community-based Data Synthesis, Analysis and Modeling of Highly Pathogenic Avian Influenza H5N1 in Asia

May 31 – June 1, 2010, Beijing, China (Scientific Presentation/Discussion)
June 2 – 4, 2010, Qinghai Lake, Qinghai, China (Field Trip)

Agenda for Scientific Presentations during May 31 – June 1, 2010
(15 to 20 minutes presentation + 5 minutes discussion)

NIH Modeling Workshop
31May-1Jun 2010

May 31, 2010 (Day 1)

8:30am – 8:50am: Workshop Introduction, Organization and Logistics (X. Xiao)

Welcome speech (5 minutes each):

Xiangyang Huang (Director of CNIC): IT Escience solutions

Scott Newman (FAO): people interested in variables involved in disease ecology, heart of modelling application to understanding and prevention

Katharine Sturm-Ramirez (NIH/FIC): Fogarty Intl Center, HHS – support of health programs, Fogarty 1 of 27 institutes, supports global health research.

Workshop Introduction: Xiangming Xiao
Workshop logistics: Ze Luo, Melissa Brown

History of Meetings:
Qingdao, 2006
Poyang Lake, 2006
Beijing CNIC, 2007
West Virginia, 2008
Bangkok, 2009
Beijing, 2010

Meeting Logistics: Luo Ze
Lunch in Conference Room:
31May 1745; bus to Quan Jude Duck
1Jun 0745: Lobby
Lunch in Conference Room:
Dinner: Hunan Cuisine
2Jun 0930: Jade Palace to Airport
Drive to Niao Dao, Dinner at Hotel
3June: SanKuaiShi Island by Boat
Egg Island, Cormorant Island
Travel Claim with Melissa

8:50am – 10:20am: Session 1. The Current Situation of HPAI H5N1 (X. Xiao)

9:50 – 9:15am Yuelong Shu (China CDC) -- Human H5N1 infection in China
Delayed, speaking second.

1. Global 500 cases reported, more than half died.
2. Pneumonia with unknown causes surveillance (2004, 2007)
3. Emergency Surveillance
4. 38 cases since 2003, 31/38 during spring-winter, 8 cases in 2009, most cases in S China, most poultry.
5. 2004 began routine surveillance; also have emergency surveillance (after outbreak)
6. 2003 case was detected by retrospective study of stored sample of pneumonia
7. Demographics – majority 15-49 age (14cases), most chance for contact, 3.5 to 7.5 d exposure to onset.
8. Incubation period – limited info; around 4d
9. Mortality rates – 62-67%, <15 age is 40% mortality, urban 82% vs. Rural 53%!!!, medical system is not as good in rural (better in urban areas)
10. Family clusters – 2 reported: 1 sister-brother, 2 days time-lag, 2 cases father-son, one could be through care, but could also be market exposure.
11. 17 cases contact w sick or dead birds (4 animal outbreaks confirmed), 9 cases live-bird market, 1 case unknown, 1 case family care
12. 30 viruses from 38 cases: genetic tree shows clade 2.3.4, majority in poultry also. One in 2009 was 2.3.2, and Qinghai Lake 2.2 (Xinjiang clade).
13. Cartography of HI table, characteristics of HPAI in China. Similar to Spanish influenza
14. Future: sporadic cases, unknown infection sources, family clusters, transmissibility could increase with reassortment or adaptive mutation
15. SN: poultry density overlaps with human cases (YS: paper is published on this), winter dynamics – people, birds, pigs. Rural communities – is there serology of cross-protection. YS: animal positive rate is low, 10,000 sera samples in rural vs. urban, so no difference detected of antibody.

9:15 – 9:35am Vincent Martin (FAO) -- Poultry outbreaks in China with highlight on the current status, and main questions for disease management

1. HPAI situation in China, ECTAD China, 3 years (2007-2009).
2. Surveillance summaries for 3 years from MOA. FAO-USAID Project, Phase IV, southeast provinces.
3. Domestic poultry outbreaks – reducing from 27 to 2, no outbreaks in 2010; Decrease in # outbreaks (last 2-3 yrs <10 outbreaks per year). In 2009 only 2 reported.
4. 2004 – start of targeted vaccination, 2005 – all must be vaccinated.
5. Provincial level surveillance efforts (by Harbin Ref Lab and provincial level CDC) all info gathered into Veterinary xx Bulletin; 2009 there were more human cases reported than in previous years (very unusual compared to other years; improvement in surveillance system).
6. Dec 2008 34 cases; April 2009 45 cases; July 2009 28 human cases.
7. 2008 5 million samples taken for monitoring and post vaccination monitoring
    a. They divided China into 4 ecological zones
        i. Zone 3 – southern China; most concentration of waterfowl population
        ii. Zone 1 – northwest; low poultry density, backyard systems

iii. Zone 2 – northeast; high poultry, high biosecurity, major trade between north and south.
iv. Zone 4 – central north; more plains, cattle, etc.

8. Map of Outbreak Locations: most in southeast, Yaoling 2005, regular localized outbreaks in west and westcentral China (wild birds)
9. Human cases and surveillance – province level, search intensified, 2009 more human cases than earlier years. Eight cases Jan-Feb 2009.
10. Human Cases and Poultry Outbreaks – 34 in Dec08, 45 Apr09, 28 Aug09.
11. 2008: 5M samples overall (2/3 for post-vaccine monitoring).
12. More viruses – perhaps surveillance improvement
13. Surveillance Provinces increasing – 60% 2007 to 90% in 2009. Positives in Jan-Jul2008, Jan-May2009.
14. Lots of samples in Guangdong with highest number of samples. Xinjiang – different poultry system, outbreak reported in 2007-2009
15. 2-3 years: repeated positive surveillance in 4 southern provinces (Guangdong, Human, Hubei, Chongqing)
16. Lots of trade N Zone II to S Zone III
17. Massive vaccination, increased surveillance, gov commitment
18. Needs: understanding of ecological areas, clade info missing since 2007, trade patterns, wild bird/domestic interface, better capacity of epidemiology, province vs. national differences
19. Questions:
    a. KSR: Seasonal patterns? Yes – most in winter or winter thru summer (Jan-Mar)
    b. RW: Diversity of clades for H5N1; even as outbreaks have declined, but southern china remains the source of multiple strains; pls talk about tension between having multiple strains but not being able to detect them. Outbreak numbers may not be good indicator of presence, more virus may be detected in surveillance and may be a better measure.

9:35– 9:55am Leo Loth (FAO) -- Poultry outbreaks in South Asia with highlight on the current status, and main questions for disease management

1. Bangladesh location, AIV in chickens.
2. 200 crew for killing 85,000 birds
3. Apr2010: Egypt, Nepal, India, Bangladesh, Vietnam, Cambodia, Indonesia
4. Bangladesh – Feb-Mar2009, Jan-Mar2010 (India, Jan2010, Nepal Feb2009)
5. Nepal, Myanmar – isolated outbreaks
6. Bhutan – outbreaks in SW near border (people, few poultry). Few chickens (3 farms (just a couple mill chickens total) and people (600K) people– surprising there were outbreaks there bc hardly any people and any chickens there.
7. Nepal – Outbreaks in higher human densities, low poultry except around Kathmandu
8. Myanmar – national duck survey 16,000 ducks on 541 farms. 2 outbreaks, 16% seropositive for H5, and 40% of flocks.
9. Bangladesh – Jan-Apr outbreaks. Most in the north early, but everywhere now
10. Phylogeny – sublineage III, little genetic differences (see graphic for genetic tree). Same clades every season. Only Clade 2.2 (same in Bhutan), Nepal (2010) and Myanmar have 2.3.2. See regional slide of clades
11. No outbreaks in India in last few months – reporting problem?
12. Trade occurs between Nepal-India-Bangladesh

13. Outbreak response – no transport, weak monitoring. Broilers in bamboo sheds, live nearby, biosecurity problems. 24-48 h mortality. 5-6 d for shed to die.
14. Only 1 human case in Bangladesh.
15. Slaughter in market, crows consume entrails, free-range ducks, open ponds, waste pumped to water bodies.
16. How does virus enter farm, where is it between outbreaks, seasonal pattern?
17. DPf: Why not more disease in Bangladesh given biosecurity challenges? LL: is strain less virulent. Is movement from farm-to-farm or markets?
18. DPf: Newcastle's disease present? LL: Yes, but not widespread. Smaller farms vaccinated, not epidemic form.
19. KSR: how good is control after outbreak? LL: Lots of outbreaks in 2007 and 2008, industry affected, stabilized now. Avoiding dead chickens sold to market – compensated for loss as replacement value, but not costs of rearing.
20. MT: Trade patterns question. LL: No market chain studies. Now being mapped.

9:55 – 10:20am Yubang He (Qinghai Lake) - Working report on epidemic disease of wild birds in Qinghai Lake National Nature Reserve

1. Qinghai Lake Reserve -- Email: qhhhyb@126.com, tel: 13897119589
2. Introduce Birds, Monitoring, AIV results, Methods
3. 4952 sq km, S. Foot of Qilian Mountains, Qinghai-Tibetan Plateau
4. Long winter, short summer.
5. Five islands
6. 189 spp of birds, waterfowl: 70,000 in migration, 20 spp.
7. 50 black-necked cranes breeding. 1500 whooper swans winter along Tie Bo Jia He River. 300,000 birds in QHL
8. Emergency Response Plan – key protected spp and regions, Wild Bird Monitoring Group – 4 groups.
9. Inspection Route -- *.swf file of route, also areas including Egg Island, Cormorant Island, BuHaHe River, and Rescue Center
10. Wild Bird monitoring –
11. BHGO Symptoms –
12. 2005: 12 spp infected, 6,253 birds died, 3,272 bhgo, 916 gbhg, 572 brhg, 1319 corm, 13 divers, 143 rush, 3 terns 1 bncr, 1 whsw, 2 ropi, 9 eagles, 2 owls.
13. Epidemics: Bird Island, BuHaHe River, HeMaHe River, 2 islands
14. 1May-18Jul: bird breeding. Peak outbreak during hatch and brood.
15. Egg Island: 7000 bhgo in 12,800 sqkm, 5000 brhg in 2800 sqkm. High density could lead to infection.
16. Peak 23-27May, from 13May – 16Jun
17. Monitoring Methods: diagnose quickly, employ plan, disinfect region, mass defense network, strengthen scientific work, viewing area (decrease human disturbance).
18. Bird Marking Studies – collaborative with USGS-FAO
19. Brown-headed gull marked in 2008 seen with PTT in 22May2010
20. RW: poultry raised in area linked to outbreak? YH: No clear relationship since local Tibetans don't raise poultry.
21. SN: climate change, 2005 May-Jun it rained often, so climate was different, unusually cold also.

10:20 – 10:40am Group Photos and Coffee Break

10:40am – 12:40pm: Session 2. Risk Factors and Spatial Analysis (Dirk Pfeiffer)

10:40 – 11:05am Marius Gilbert (UL) -- Risk factors and spatial analysis in Southeast and South Asia: a review

1. Literature search (Apr 2010)– Web of Sci, CAB abstracts. AI, spatial risk cluster map distribution
2. 70 papers – 6 categories (empirical studies w AIV dist data n=36). Talk Focus.
3. Wild bird patterns assess risk (n = 15), Poultry product and trade and risk (n=5), Math modelling (n=6), Molecular ecology with spatial component (n =5), Review paper (n=3)
4. I. Descriptive (n=5)
    a. Kilpatrick et al 2006 – wild bird trade
    b. Park and Glass 2007 – human and seasonality
    c. Sengupta etal 2007 – continental scle ecology
    d. Cecchi etal 2008 – Nigeria
    e. Tiensin etal 2007 -- Thailand
5. II. Space-time statistics (n=6): 1 continental, country (Romania 2, Vietnam 1,)
    a. Si etal 2009: space time clusters in waders, related to wild birds, not formally tested.
    b. Ward etal 2008 – Romania, space-time stats
    c. Farnsworth etal 2009 – elaborate analysis
    d. Minh etal 2009 – Vietnam
    e. Souris etal 2010 – intro points
    f. Oyana etal 2009—China distribution, inconclusive
6. III. Risk-factor geospatial analyses (n=21)
7. Six studies examined 1-2 factors (temp, wild birds)
    a. Rivas etal 2010-- Nigeria, roads
    b. Ottaviana and Reperant 2010 – temp isoline
    c. Ward etal 2009 – wild birds
    d. Kuo etal 2009 – trade as predictor of human cases
    e. Li etal 2004 – H5N1 outbreask in China, distance to railroads
8. Methods – mostly logistic regression, ecological niche modelling
9. Risk factors: poultry, people, wild birds, ecoclimate, landcro, water, topography, socioeco
    a. Poultry – risk factors varies a lot, density of hosts
    b. Human factors – distance, density
    c. Wild birds – risk factor Bangladesh contact
    d. Ecoclimate – NDVI, precip
10. Poultry – depends on scale and production system
11. Duck effect clear in Thailand and Vietnam
12. Human – higher density, roads, close to roads, none – more specific on mechanism
13. Wild Birds – effect studies non-existent on risk.
14. Ecoclimate – lack of causal interp
15. Landuse – rice, aquaculture. Animal densities, irrigation
16. Water – near water, %water positive
17. Topography – floodplain points
18. Socioeconomic – weak
19. Egypt and Indonesia – weak info (0-1 papers) on human cases
20. Thailand, Vietnam, China – more papers (3-5)
21. Recommend: geography, trade, wild birds, production, water-borne
22. RW: synergies in a country, how to test.

a. Questions: (RW) talk about tension bw doing factorial design and what seems to be emerging about local synergistic associations (happens in one country and not another)? MG sees the tensions there – so have on one hand descriptive comprehensive studies and on the other hand have analysis on more restrictive set of associations. (??) What is your definition of dependent variable (risk of spread, risk of introduction, risk of what?) – it's the risk of presence of H5N1.

11:05 – 11:30am Vincent Martin (FAO) -- Risk factors and spatial analysis in China

1. A. Risk modelling from database; B. trade and social network
2. A. Risk Model: environ, human, risk population
3. Technique – logistic regression, boosted regression trees
4. Variable: chicken density, human population, Rice%, Water%
5. BRT – profile of risk factors
6. Creates Risk Maps –
7. B. Social Risk – 10 markets per province, questionnaires, network.
8. LBM ego-networks of China – each market is a node, degree is skewed (catchment – where poultry come from), market nodes – highest degree
9. K-core indicators: each node has at least k degrees (2-core, 3-core, etc)
10. Markets vs. Outbreaks, surveillance, human cases
11. Find higher risk markets for surveillance
12. RW: Need sequences or phylogeography differs from database (risk model above)
13. VM: different samples.
14. KSR: majority of viruses are low path, extreme virus, not ecology overall, not static
15. JO: what drives these long movements? Production in north, import in south. Trade N. China to Vietnam.

11:30 – 11:55am Leo Loth (FAO) – Poultry outbreaks in Indonesia

1. Indonesia study – focus on Bali, Jaffa, and area, 2006-2007, outbreaks per visit, no temporal analysis, only spatial. Lower coverage in 2006.
2. Positive Districts – up to 20% or seldom
3. Logistic models: bootstrap 500 times
4. Predicting districts unsurveyed – prevalence was estimated.
5. Commercial poultry areas high, backyard poultry has outbreaks (as spillover), transport is significant
6. Rice cropping high, ducks not high
7. Q: villages under surveillance better than visits. Visit is likely done because of call-up as active surveillance 5K of 136K is positive, (Q: but 98% is passive detection).

11:55 – 12:20pm Lin Zhang and Zhongwei Guo (IOZ) -- Risk assessment of highly pathogenic avian influenza in China

1. Jiangxi Province, Poyang Lake – cropland surrounding
2. Inner region analysis: temp (for migr. Birds) and cropland overlay, grouped into 12-mo period, 5 classes. Crop attributed 1-4.
3. Duck Density, Poultry productivity – ton/d, Land use
4. Migr Birds and Domestic Poultry made weighted layer
5. Inter-local analyses: also add road layer, poultry dens, human, landuse, temp. Corridors connect hotspots (Nat Hwy 105, 206, 320).

6. Trend Analysis –2 high risk areas for province. Changes greatly through a year.
7. 99 counties in Jiangxi—poultry trend, productivity, turnover
8. MG: how weighting of risk factors done to make risk maps: (answer) – using literature. 2 layers 10%, 6 layers 20% to highlight routes
9. Q: relation of Qinghai vs. Poyang and wild birds? She doesn't have that data. Hotspot – outbreaks happen, risks of H5N1.

12:20 – 12:45pm Zhaojun Fan (WIV/CAS) – The Virus Resource Database in WIV and its applications

1. Virus resource database --
2. Multiple users – platform for sharing
3. Building the resource platform --
4. User Interface – different for each user
5. Questions – (DF) currently public? Some data is not able to be released publicly bc national policy or bc some data is not published. (SN) once the data will be publicly available, what is the policy of the database to get into the public domain? Maybe put it into a public database such as GenBank.

12:45pm – 1:30pm Lunch (working lunch in CNIC)

<u>1:30pm – 3:10pm: Session 3: Poultry Production Systems and Trade (Scott Newman)</u>

1:30 – 1:55pm Robert Wallace (UM) -- Does Southern China's historical present shape influenza's evolution?

1. How do we work together? – different disciplines
2. Not just concatenating datasets, thought processes are different. Need to assimilate others viewpoints.
3. Niche Map – agro-ecological areas (Hogerwerf etal, submitted) , Ag, ducks, chickens, funds
4. Economic geography – rate across S. and E. China, mostly contiguous. Shared climate and environ. Regional ag varies. Ducks in rice paddies for pest control 500 ya. Rice-Duck-Modern Poultry intensification followed regional development.
5. Integration – duck domestication 3000ya, rice in fields 500ya (Ming Dynasty), ducks control locusts (Fujian). 16th century – ducks held on boats, fed out in environ. Ducks transported by water, 2000/boat, fed on river, dealers salted and dried birds.
6. Shifting agro-ecosystems: rice-fish farming system, mulberry-silk-fish system. Integrated farming is regional (Guangdong -- Pearl River Delta). In past 2000 years. Increased siltation, diked-pond system. Related to global and local economies.
7. Paddy rice –cropping with less labor, recycle grain waste. Shift in society (Maoist reform). Doubling population shifted to grain production. Rice-fish farming in late 1950s (40,000 to 320 ha by cultural revolution)
8. Communes – optimizing (rice, silkworms, chickens, ducks, pigs).
9. Late 1970s – more foods and goods w intl trade in spec. Econ zones of S. China.
10. 1979-2004 – foreign direct investment 0 to billions
11. Chicken farming grew 7% per year 1961-2006.

12. 1997 – first H5N1, Guangdong top 3 in poultry. Feed mills, processing plants. Coastal provinces (profitable poultry) outcompeted inland (cheap grain). Increased scope occurred with inland development.
13. Pearl River Delta – unprecedented density, affecting influenza evolution. 1989 – compact cities, 1997- wide urbanization. Also, rise of aquaculture (greater profit).
14. Questions: locations and practices, proximity to duck-fish, present day siting, spatial synergies changed?, are mixed landscapes producing vulnerable niches, reflection of past and present together.

1:55 – 2:20pm Diann Prosser (USGS) -- Poultry distribution models for China and Monsoon Asia

1. Gridded livestock of world (GLW), 1km, 1990s, not spp level
2. FAO Farms v. 1.0
3. Obtain Data – suitable areas – prediction
4. 14 countries – Monsoon Asia. Level 1-3 (3 = county level data)
5. China – county-level, 3. Nat Stat Bureau, 2. MOA Animal Husbandry, but highly correlated. Fill method.
6. More people, more poultry, better data.
7. Provincial Spp data – applied to total numbers chickens, ducks, geese.
8. Suitability Masks – orig GLW was for poulty and pigs. Conservative masking approach here: High elevation, dry areas. Adjusted data.
9. Regression to disaggregate data – finer spatial 1km, explore effects of predictor variables, stratification schemes.
10. GLW – Modis: data seasonality, human, distances, geography
11. LU – Landcover, cropping, humans, elevation, slope
12. Stratification – Modis, GLW, Agro-Eco Regions and Best of All
13. Sampling for Training and Validation – 1 point per polygon (0.002 pt/km2)
14. Stepwise regression by AIC – 25 bootstrap layers, mean and CV. Good of Fit = RMSE, Correlation, 25% reserved for validation.
15. Max Dens – 3000 ducks/km2, 10000 chickens/km2, 300 geese/km2
16. Varying scale – can overpredict density.
17. Now have species level spatial distn, ready for modelling at 1km.
18. KSR – availability: China will be avail on USGS webpage, then on GLW webpage by FAO

2:20 – 2:55pm Tim Robinson and Joachim Otte (FAO) – Drivers, projections, and consequences of poultry demand in Asia (team presentation, 30 minutes plus discussion)

1. Human demographics – 1.2B people, rural decrease, 40% of China in cities, 1990 was 25%. Indi – all growing, slower urbanization.
2. Highest densities in China – Szechuan plateau, Beijing zone
3. Highest density in India – highest in Ganges plain and NE China, more even, more rural.
4. China – fewer large cities, smaller cities increased
5. India – more large cities
6. Purchasing parity – same GDP in 1990, but 5x higher in 2008, India is 3x greater.
7. High income: 0.10 is food,, 0.90 on other; China 55% on food; India, 55% food
8. China: 25kg/yr to 50 kg/yr, poultry growth highest from 7kg to 13kg
9. India: 5kg meat
10. China -– Pork doubled production 1990-2008, but poultry grown 100 to 500 although pigs is bigger. Higher offtake rate.

11. China pig – exports, poultry is both export and import
12. Farm Density (Binsheng and Yijun 2007) – fewer farms 1990-2005 dramatically concentrated. Large farms >50K are in coastal provinces (30% of farms). Driver for disease?
13. Broiler – few farms (0.5% of poultry farms), but 50% of poultry meat
14. Layers -- <1%, 40% of eggs, concentrated greatly from 1996-2005.
15. Intensive Systems –
16. Environmental approach – "other" can dominate the imagery.
17. Demand-based approach – surplus and deficit, NE China is surplus. Chickens in North moving to south. Transport cost (lower than revenue) to raise in north.
18. Does disease drive concentration or vice versa?
19. Need fine definitions about types – backyard, small holder. Need to know local drivers (analyses are biased toward easily available data).
20. XMX – India have limited poultry production areas, many vegetarians (culture, religion). How do you bring factors into the model? Look at consumption (historical present). Different zones shaping culture.
21. RW: what else can you do over spatial models? JO: use business models, other approaches. Don't use your own preferences.

2:55 – 3:15pm Eric Brum (FAO/Indonesia) – Potential use of longitudinal market chain surveillance in Indonesia to better understand HPAI risk in commercial poultry and to assess national HPAI control program efficacy

1. ECTAD Indonesia
2. Large village populations – broiler 69% (930M), native 19% (262M), no compensation, vet services decentralized to districts
3. Seasonal pattern peak Feb-Mar
4. Central Java to Western Java and Sumatra – most affected
5. Human Cases – W. Java, Jakarta, seasonal
6. Jakarta- lowest native chickens and case rate
7. Assess risk to lead to action.
8. Traders – show movement patterns, motorcycles major movement
9. Live bird market – assesses HPAI control efficiency, 50% were positive each month, half were H5 positive.
10. Collector yards – types of birds
11. Sick and Dead – not a reliable test, logged truck movements, sentinel birds, truck movement is at night. Sentinel birds death changed behaviour (moved birds to clean areas, washed hands, etc). Possibly aerosol is a means of transmission to sentinel birds.
12. Question: (XMX) seasonality of poultry outbreaks – any regional differences? Most of the outbreaks that occur in central/w Java see seasonal occurrence.

3:15pm – 3:30pm: Coffee Break

<u>3:30pm – 5:35pm: Session 4: Water Bird Movement, Trade and Production (Vincent Martin)</u>

3:30 – 3:55pm John Takekawa (USGS) -- Wild bird telemetry in China and South Asia: A review

3:55 – 4:20pm Ioannis Xenarios (Switzerland) – Virus Sequence database system (TBC, teleconference from Switzerland)

1. By teleconference
2. Sequences centered around isolates. Can switch from DNA to protein
3. Genomic sequence by click – quality control is reported in metadata.
4. Epidemiology and genetics – tools available. Use open source for alignments (Muscle, JalView, PhyloWidget, Blast). JalView shows changes, PhyloWidget shows view by isolates. Blast shows nucleic and protein sequences. Geolocations and statistics with Google API. Sequence similarity maps.
5. Automatic import – GenBank (NCBI) to OpenFlu
6. Curation – biocurators. Sequences 119,497 in GenBank, 106713 for OpenFlu. GenBank can't modify entry, only authors.
7. http://openflu.vital-it.ch/browse.php

4:20 – 4:45pm Scott Newman (FAO) -- Wild bird farming and trade: A review

1. moved to tomorrow

4:45 – 5:10pm Peng Cui (IOZ/CAS) – Wild bird migration and risk for H5N1 transmission into Qinghai Lake, China

1. Qinghai Lake – mixing area of wintering and breeding birds, low human disturbance
2. Species, Optimal Sites
3. Potential Risk sites – from Pfeiffer etal 2006: >100 birds of spp
4. Bird surveys 2007-2008 (Mar-Dec, 22 sites, 4 periods)
5. Risk per species = abundance (A) x prevalence (P) x efficiency prob of transmit to another (Ei) x virus titer (Vt) x duration shedding (Vd)
6. habitat (H) x temp (T) x Sum (AxEi xMr) x Sum (Risk per species), where Mr = morbidity rate
7. Kou etal 2009 – see prevalence rate, analytic hierarchical process method
8. Ei = DM xW +GS xWgs =GD x Wgd + FM x Wfm
9. 14 species high risk in the spring – 9 from Anatidae 56% of high risk
10. Highest risk species is GBHG, then BHGO, comorant, 2 ducks
11. Common Pochard – highest risk of ducks
12. Risk assessed at local scale and specific sites

5:10 – 5:35pm Doug Watkins (Wetlands International – Current Waterbird Monitoring Programs in Asia – Opportunities for Collaboration

1. Multilateral conventions or bilateral agreements
2. East Asian-Australasian Flyway partnership
3. Int Waterbird Census – 1967 start, volunteers, Asian Waterbird Census (25 countries, 6700 sites, national coordinators, AWC database coordinated by WI).
4. TRIM – trend and SE estimates
5. Eaaflyway.net
6. Questions: (SN) Info accessibility – publications are available, need to contact WI.

6:00 – 8:00pm: Dinner (all the participants)

June 1, 2010 (Day 2)

8:15am – 9:30am: Session 5: Models and Decision Support Tools for Avian Influenza (Marius Gilbert)

8:15 – 8:40am Dirk Pfeiffer and Kim Stevens (UK) -- An overview of Spatial multi-criteria decision making models for defining HPAI H5N1 suitability in Asia/Africa

1. Data-driven Models: regression, wt of evidence, neural networks, classification-tree
2. Knowledge-driven models: quantitative/qualitative knowledge, multi-criteria decision models, simulation models; What you're trying to predict is the most likely occurrence (use data to validate the model)
3. Decision – alternative choices; criterion – evidence to decide; decision rule – procedure for selection; objective – structure decision rules
4. Evaluation – applying decision rules; Boolean overlays, weighted linear combination (wts for pairwise comparison)
5. Uncertainty – database, decision rule (fuzzy vs crisp sets)
6. Decision risk – likelihood of being wrong – Bayesian
7. Hard decisions – Boolean decisions with perfect data
8. Soft decisions – probabilistic – likelihood
9. Fuzzy sets – irrigated land indicates AI risk (5% high); use crisp set (>5% = high, <5% low); or have risk described as a function high AI risk = f (% irrigated land)
10. Dempster-Shafer Theory: Bayesian, data uncertainty in calculation "belief in hypothesis not complement of belief in the negative" collect different evidence for presence/absence, combine for hypothesis. Belief – total support, degree of hard evidence; Plausibility – degree can't be disbelieved, conditions that appear right although hard evidence lacking; Belief Interval – degree of uncertainty in presence/absence. Risk facts weights for introduction add to 1.0 (fuzzy membership values, function), same for endemicity.
11. Risk of H5N1 introduction (trade): assuming exposure, will it sustain (risk mgmt not included)
12. Validation – use outbreaks
13. Outbreaks by suitability category, cumulative shows 80% of outbreaks in 30% of land mass. Belief map in suitability
14. Africa – similar validation of MCDM suitability map – 97.4% in 3 areas. No outbreaks in Morocco – why? Lack of exposure of wild birds or trade? Not a risk map, a suitability map. It scales within area.
15. Conclusions: expert knowledge to set parameters in model can be biased.
16. Risk management – can use maps to focus.
17. Introduction is separate from endemicity – modelled separately

8:40 – 9:05am Mike Tildesley (UK) -- A review on mathematical models and its use for HPAI

1. A. Develop model of historic infection in Vietnam and Thailand. B. Evaluate role of ducks. C. Investigate intervention strategies, D.
2. The data: A. poultry at subdistrict level 3, commune level (16km2). B. Remote sensing data on smallholders and freegrazing ducks. C. Regional infection data (date, location, total birds, birds infected, birds destroyed). The data are not good enough.
3. FMD example-- 2001 and small 2007: detailed demographics, epidemics on farms in England. USA has number farms, number animals, movement of animals, no epidemic info (only 1930s), US county >>16km2

4. Random Maps – random locations good enough? 3000 counties in USA, but Lancaster, PA has good data. Parameterize – don't know precise locations of farms, only reported farms. Ring culling radius is 4km for both datasets.
5. Effect of clustering – most highly clustered, random model performs well. Better to over-cull than under-cull.
6. Role of Ducks: transmission rates (same rate of sheep and cattle, cattle more susceptible but no info on pigs). Denmark epidemic – need a lower level to start.
7. Hot spots correlated, disease persistence without ducks,
8. Is vaccination better than culling. 2001 – culling bordering farms, dangerous contact (DC) culling – prompt 24-h cull is better for control. Vaccine targeting – outside-in or inside-out, large cattle farms, large mixed farms, random. Largest farm targeting was best.

9:05– 9:30am Robert Wallace (UM) -- Rock-paper-scissors: Can we integrate influenza phylogeography, ecological niche modelling and spatially coded time series?

1. Integrating multiple datasets: time series, Souris etal. 2010, H5N1 incidence to predict primary outbreaks vs. Secondary. Avg distance to 2 neighbors, % of points with neighbour in set.
2. Emergence – Thailand and Laos <10km, 21 d; 300km threshold
3. Strange difference in natural and human factors, ad hoc assumptions of causality. What is statistical independence? No gold standard of genetic matches between localities
4. Phylogeography – can identify matches (James etal 2007, Wallace etal 2007). Map migration matrices. Hovemoller etal 2010 – used trees and compared outgoing vs.incoming relationship (failed to detect many pathways).
5. A single process can produce different trees depending on individuals sampled.
6. Lemay etal 2009 – confirmed migration analysis, Bayesian phylogeography, can map with biased distribution.
7. Limitations – migration events inferred among localities in analysis. No power analyses (representative sample), simplicity of migration models.
8. Ecological Niche Models – (Williams etal 2008): need causality to filter climate and environ layers. Assigns static eco risks to moving targets, and omits community effects (competitors), omits starting conditions.
9. Continuous phylogeography – done by coordinates. **Leme et al. 2010**
10. Phylogeny and time series (Russell et al. 2008) – H3N2 spread
11. Time series and skyline plots (Vjaykrishna etal. 2008) –
12. Phylogeography and niche modelling (wallan etal 2007)
13. Phylogeo and molecular evolution – Hill etal. 2009
14. Leache etal 2009 – Phylogeny, niches, and morph
15. Integration: methods can infect each other rather than cover limitations. Cross-validation Lam et al. 2008, most recent common ancestor (MRCA): Indonesia invasion – assumption of panmixis. (Excoffier etal 2009)
16. Sampling effort and periods should match extent and depth.
17. Landscape phylogeography -- application of wild bird telem, agroeco niche models, risk mapping commodity chain, and intervention planning.

9:30am – 9:45am: Coffee Break

9:45am – 11:30am Session 6: Field Study on Human-Poultry-Wild Birds Interface (Michael Tildesley)

9:45 – 10:10am Scott Newman (FAO), Xiangming Xiao (OU), and Changqing Ding (BFU) -- An update on integrated field study in Poyang Lake, Jiangxi, China

1. Farming of wild animal species worldwide – wildlife is the source for majority of diseases (Asia: reptiles, small mammals, bears, tigers, monkeys, wild fowl). Driven by cultural preferences – bushmeat in central Africa (>1B kg annually, Wilke and Carpenter 1999). Amazon – 67-154M kg. Urban-driven lucrative market.
2. Depletion by hunting increases demand. Regulation is not MOA, typically resource ministry that usually doesn't manage this. Industry not tracked well. Wildlife farms are undocumented, unregulated.
3. Crowded areas, species mixes, wet markets have both in small areas, shipping across distances. Farmed wildlife and infectious diseases. Wildlife are sold in large numbers as medicinal products.
4. Interface studies – Poyang Lake: 25M ducks, 3M geese, 21M chickens, 1M wild birds, 6M people.
5. Agriculture System – poultry production, AIV sampling, paddy rice and water, contact rates wild birds-poultry-human, geospatial application
6. Fieldwork: village level Ag production data, Market chain study – Nanchang market, duck farm surveys, duck farm locations and sizes, meat or layer ducks, calendar, free-grazing
7. Data logger study: 11 duck farms, 40 GPS loggers, >8000 locations
8. Rice paddy agriculture – rice cropping, calendar, biomass, field observations – leaf area change (LAI). Closed canopy is without duck in the rice paddy.
9. Wild Bird Farms – 16 farms, 10 sampled. 2 geese (SWGO, GLGO), 7 ducks (MALL, SPBI, RUSH, others). Graze in fields 56%, caged – only 1 farm, both is 38%. 72% had poultry on same premises, 57% reported wild birds on farms (only 2 had sign. Interactions). Vaccination – 11/14 farms vaccinated, no standard protocol – all schedules. 31% have fixed customers, 69% market outside (5 farms only outside), some birds moving 1500km.
10. Wildlife surveillance – not possible (permit process), domestic ducks 2009, farmed wild birds 2010, future --- human serology?
11. Implications: same wetland use, more mixing, close contact with domestics, vaccine use varies, long distance marketing.
12. Questions: what is extent, other countries, growing market?

10:10 – 10:35am Ze Luo (CNIC) – An update on field study in Qinghai Lake, Qinghai, China

1. Joint Research Center – CNIC and 6 institutes
2. Network monitoring system -- 19 webcamera systems, allows detection of AIV outbreaks, analysis of motion, learned about territorial behaviour on male in early breeding, and behaviour of female while brooding. (Qinghai Univ. – paper on behaviour from time series)
3. PDA Data collection –
4. DNA barcoding – species ID
5. Survey results database – varied graphics
6. Spatial analysis – to relational database, density based data mining in clusters, model based prediction from ecological factors from landsat, habitat niche prediction.

7. AIV transmission – genetic analyses
8. Data integration and mgmt – Sensor Network (CNGI) as example project, spatial dist analysis

10:35 – 10:55am Katharine Sturm-Ramirez (NIH/FIC) – Introduction and update on Avian Influenza Collaborative Project

1. NIH -- 27 centers; budget is 30 billion
2. 50,000 grants, 325K researchers, 3000 institutes (80% of budget)
3. Promoting health around globe --- 5% of NIH, 64M/yr (0.5% of NIH budget), $60M in grants (1/3 research) and building capacity, 75 employees. Work in
4. 4 divisions: Epidemiology and Populations, Intl Training and Research (KSR works here)
5. Focus – math modelling, research capacity building of foreign scientists
6. Cross-species transmission: wild aquatic bird reservoir (wheel of flu), rapid evolution in new hosts, intestinal in wild birds vs. Respiratory in humans. H1-H3 in people, H1, H3 in pigs, H3, H7 in horses. H5, H7, H9 occurred in people without stable lineage.
7. Overarching math model from empirical data – predict risk of transmission, identify factors underlying risk of spillover, predict where it will occur
8. Collaborators: E. Birmingham, P. Dazak WT, R. Gilman John Hopkins, J. Montgomery Navy in Peru, T. Smith UCLA, X. Xiao OU, KSR and Josh Rosenthal FIC (started Oct 2009)
9. Countries: Panama, Peru, Cameroon, Egypt, Bangladesh, China. Core set of variables: sampling field observations (wild-domestic), field questions, diagnostics, spatial modelling, collaboration software, meetings, FIC coordination
10. Common Data Variables: virus, host, humans, farming, environ, socio-cultural
11. Cross species transmission – want to look at more strains
12. Swab surveillance – RNA extraction – AIV A test – send to reference lab in Viral Isolation – full genome sequencing and subtypes of H, N (high and low path for H5, H7)
13. Modeling - Parviez Hosseini, WT: who-aquires-infection-from-whom (WAIFW) matrix. Patterns and practices across nations (SIR model).
14. Fund ok for FY10, fieldwork continues, expand sites?
15. Multinational Influenza Seasonal Mortality Study (MISMS) – transmission patterns
16. PLoS Currents: Influenza – moderated blog online. Can publish in peer-reviewed journal elsewhere but citable.
17. Migration analysis 2007: Ivory coast to Ghana and Nigeria to Togo.

10:55 – 11:20am Kurt Vandegrift (Wildlife Trust) – Elucidating the mechanisms behind H5N1's persistence in Bangladesh: A potential role for wild birds

1. Wild birds in Bangladesh, WT (senior postdoc fellow): goal of Kilpatrick model to H5N1 (PNAS)
2. Pandemic H5N1 cost – $70-166B
3. In SE Asia poultry; to Europe migratory birds.
4. Contact rates –
5. H1N1 surprise – from Mexico (lack of surveillance), not around since 1918. Global aviation network (MX to NZ in 1 mo). Huffnagle etal 2004 PNAS. IATA data to predict spread.
6. PREDICT –
7. Wild Birds – persistence; infected transport by waterfowl; role of wet markets, variables of markets

11:20am – 12:35pm: Session 7: Cyber-based Data and Model Integration (John Takekawa)

11:20 – 11:45am Zhiyi Huang (CNIC) – Data integration and application in Qinghai Lake

1. Student of Yan, since 2007
2. Sci activities, sci data, research and applications
3. GPS data -- >800,000 records 2007-2010, Ducks >200,000 records
4. DNA barcodes
5. Annual virus tests
6. Bird and vegetation surveillance
7. Data collection – GPS data from Argos tracking system
8. Mobie Data Acquisition System – Palm-PC-Server (XML file)
9. Architecture – application-integration-collection-web management system
10. Stat analysis – cluster, migration mining, H-correlated habitats
11. Data mining papers – separate authors

11:45 – 12:10pm Scott Newman (FAO) -- MOVEBANK

1. Movebank – Roland Kays and Martin Wikelski, Archival system for radio-tracked animals. Open access and sharing.
2. >228 studies, >800 bird tracks, >273 users
3. Permission and passwords required. Living will for researchers.
4. Standards, Org, Mgmt Tools –
5. Data uploading, use of remote sensing datasets
6. Gil Bohrer – weather data
7. Collaboration online – increase sample size, geographic scope, temporal scope, taxonomic scope, increase range of questions, outreach and education (Nat Geo, Freedom to Roam, GE, Science Buddies)
8. Community.Movebank.org – sharing info
9. Funding – NSF, Max Planck, NYS Museum, Smithsonian Trop Res. Inst.
10. FAO – integrating cross-connectivity with different databases

12:10 – 12:35pm Xiangming Xiao (OU) – Cyber-based data-model integration

1. Earth Observing and Modeling (OU) – http://eomf-dev.ou.edu
2. Disease Ecology and Forecasting – framework for ecology, risk assessment, avian influenza
3. Datasets – Data Analysis (Geospatial, IBM, Sp Dist, Agent-based, Stat/math) for Nowcast and early warning – Decision Support Systems
4. Data Collection challenges – variety, timeliness, accuracy, geolocation, sources
5. Citizen science – GPS photos, www.eomf.ou.edu/photos -- case study for India. Management of photos.
6. Integration and visualization – photo, time series satellite data. Optical sensors (Modis, Landsat), synthetic aperature radar , others
7. Global map of agriculture datasets – Modis – 8d, pixel analysis – cropping (crops/yr), calendar (plant and harvest), water (inundation). Paddy rice and crop intensity.
8. Palsar data through classification to agriculture dynamic data for region.
9. ScanSAR rice products for rice, hydroperiod.
10. Weather Data – H5N1 outbreaks,
11. Webportal: http://www.eomf.ou.edu
12. Google.org – data mining. Seasonal flu in USA,

12:35pm – 1:30pm: Lunch at CNIC (working lunch)

1:30pm – 2:30pm: Session 8: A tour of the CNIC (Ze Luo)

2:30pm – 4:00pm: Session 9: Group Discussion on Data and Model Integration (TBD)

Open discussion on data-model integration, work plan, publication plan, and grant applications

1. Workshop Objectives: **identify geospatial datsets, identify major gaps in knowledge**
2. Facility capacity building for a network

Joint Data Analysis – (Notes I)

1. Data exists but not integrated
   A. Poultry models – est of populations, need biosecurity measure. Scale?
   B. Virology – lack of infection data (data on outbreaks). Needs to have surveillance program – negative data, 750K samples on wildlife. Ducks vs. Pigs. Only HA and H5 – need the rest of the viruses (In 1997 outbreak, 6 genes were H9N2 outbreak in HK). H vs N vs internal genes.
   C. Waterbird Datasets – not much asked about it. Spatial point datsets on congregations.
   D. Domestic ducks have fewer samples than needed – unreliable market data (sample quality). Backyard vs. farms needed for mapping (see A).
   E. Geographical Areas – with information already available.
   F. Transmission data – lab studies to look at this (chicken and duck)
   G. Seasonality of outbreaks – bigger look at this picture. Relate to Phylogenetic Trees. Compare human flu vs. avian flu (use latitude to divide, poultry density).
   H. Information on virus locations.
   I. Market chain information – not tracked.
   J. What Questions do we want to Ask? – start here. 2009 to 2010 Notes.
   K. Bangkok Review – epidemiology across sectors (see Poyang), Sharing data issues (increasing databases like Movebank), message is being sent, qualitative vs. quantitative, clusters production and customers, free-grazing ducks and shipment (no answer), sat data for ownership, China better understanding.
   L. Poyang, Central Asian Flyway – wild bird tracking, need phylogenies
   M. China -- Poyang and Qinghai Lake, particularly important. Different flyways, no GPS link between, other species may be important, phylogeny analysis viruses traced to earlier sequences from Poyang, molecular marker, subpopulation connectivity, 2005 clade 2.2, 2006-2008 same genotype, 2009 different genotype, decreasing prevalence rate in waterfowl (old viruses are not there). Sampling 2.2.3. Now sampling 2x per year at Qinghai.
   N. Vaccine use is not well known – less regulated than human, what is the type? For China, model shows protective effect from vaccination. May protect against disease but not shedding. OFFLU network data.
   O. Duck farmer serology sampling – interface of human and poultry (also pigs). China CDC has studies (also Vietnam, HK, China) -– less known.
   P. How does the industry work? Cross-border research in S. Asia by FAO. Qualitative (illegal to trade). SE Asia FAO study, 10 countries. Lacking data on

commodities spatial flow. Could look at price differential and supply (chicken types, eggs, 1-d chicks and ducks), deficit maps.

Q. Geographic redistribution of 2.3.2 (Nepal, Bhutan, not in Bangladesh) – now going to Europe. Focal assessment.
R. Cases in Indonesia of ducks in Sector IV, fewer cases in Egypt and elsewhere. Why? 7,000 outbreaks since 2006. Data in EMPRES, active surveillance can find it. Request before use.
S. National origin destination survey – Indonesia shipping file.
T. Maintain the Series of Workshops – Community-based data synthesis and analyses. Could use virologist presence.
U. HongKong September – options for influenza control (triennial) -- human.
V. Workshop group – maintaining the contacts through time. Use of subgroups?
W. People – virology,
X. Review Papers:
   Truths about AIV – lit review by discipline (dogmas set w/o knowledge): RW lead
   Central Asia Flyway integrated analyses
   East-Asia Australasia integrated analyses
   CAF, EAF Comparison Proposal (JYT lead – MGilbert, DWatkins, SNewman, DProsser, CAS?) – outlet with CAS, see XMX for NIH Modeling of Infectious Disease Agent Systems, NSF Ecology of Infectious Diseases, Google Foundation (Project Earth Engine – request resources, not funds)
   Asia-wide Risk Assessment (PNAS II) – XMX
   Poyang Lake Integrated Analysis –SN, add human health
   Knowledge-based Modeling – DPfeiffer
   Review of (spatial) model techniques & application to H5N1 in East/South Asia – Marius, XMX (Chinese literature)
   Phylogeography of AIV – RB, list paper of the workshop
   Modeling on data for India/Bangladesh and control efforts from outbreaks record including human (LL)
   Poultry Production System Mapping—TR, JO

Joint data analysis – group brainstorm (Notes II).

-data gaps not yet integrated into models
-gaps in knowledge
-additional disciplines to engage

-(DJP) poultry modeling (assessment of biosecurity or farm type)
-(KSR) virology – asymptomatic infection
-(SN) wildlife bird samples 0.75million (mainly negatives) – can we access that data
-(DW) there is waterbird data that could be included
-(JO) sample quality dimension (MYM)
-(KSR) transmission data (eg. Putting ducks with chickens in lab…)
-(LL) seasonality of outbreaks: mostly beginning of year – let's have a broader look at why this might be happening at different locations
-(DPf) Market chains, how are the domestic birds moved around
-(SN) We still need to get more info about the viruses that have been isolated (source, better geolocation)
-(KSR) vaccines – how much are they driving the virus
-(VM) provinces with higher vacc have lower risk of disease
-(EB) might be helpful to get more info from within the poultry industry
-(LL) FAO study looking at poultry trade 10 countries
-(RW) let's talk about what questions we want to ask; mental note of diff in the past year. We've actually made quite a bit of progress in the past year.

From Bangkok mtg (and now):
-poor understanding in epidemiology in agriculture and across sectors (maybe same)
-issues of sharing data (moving forward here – movebank, etc.)
-relationship bw qualitative and quantitative analysis (
-where do customers cluster, where does production cluster? (this year we had several presentations that show maps of market connection (V)..)
-need estimates of free grazing ducks and shipments
-can satellite ms extent of cropping; can use RS to tell you about ownership?
-china was question mark

-(MG) this group is cross-disciplinary; what are the areas or units where we do have a critical mass of information across disciplines that will allow us to address questions in an original way.

-PYL study has all the pieces
-region of interest – central asian flyway

-(LFM) phylogeny work over past 2 years – identify QHL and PYL as important areas
And 2005 → 2006, 2007, 2008 same but 2009 different

-Do we have enough info to tease apart why the 2 china systems are different (QHL, PYL)?
-(SN) new 2.3.2 clade –
-(RW) maybe it's also how the actors are arranged in space (maybe also look at age density)
How and why do such landscapes change?

-(EB) something he's seen in Indonesia and not necessarily in other countries is many reports in sector 4 (7000 unique cases since 2004) but in Indonesia there's also complete lack of data on commercial poultry

1. should we have another meeting? Generally – yes but maybe expand themes
-virology, public health contribution
-future workshop with themes
-pick a couple projects with integrated collaboration – need more satellite meetings or communications

2. contributed effort to review in a thematic way.

-(KSR) the work by this group could help reset some of the dogmas that have been established in a vacuum of knowledge
-(RW) would be task master for review paper from this workshop
-suggestion of comparison bw CAF and EAF
-(JYT) Target proposal – to MOST or NSF EID
-John to lead, Doug Watkins, Taej Mundkur, Scott Newman,
-(XMX) Asia wide risk assessment? (MG says the review will help with that). Compare a data driven model with knowledge based model
-Poyang Lake integrated analysis
-Knowledge Based Modeling (DPf) – combination of expertise from a group gives credibility
-(MG) Review of spatial model techniques and application to h5n1 review in east/south asia
-(LL) Model for management of AI in Bangladesh
-(TR) Make some progress with poultry production system mapping; address issues of intensification, drivers, etc.

3. Grant opportunities – (JYT) MOST, (XMX) US NSF EID, (KSR) Google Foundation (Project Earth Engine) (TR said that they stopped funding grants)

QUESTIONS:

*Integrated farming – historical process, but changed through time in landscape. How has it changed through time (edge density?)
*Solidify moving forward with a few ideas.

2. Gaps in Knowledge
3. Additional Disciplines

4:00 – 4:15pm Coffee break

4:15pm – 5:30pm: Reserved for Subgroup Discussion and Collaboration

6:00pm – 8:00pm: Dinner (all the participants)

Draft Plan for field trip in Qinghai Lake, Qinghai Province, China (June 2 – 4, 2010)

A 3-day field trip to Qinghai Lake is planned (to be optional for participants; 1st day from Beijing->Xining->Qinghai Lake, 2nd day in Qinghai Lake, 3rd day return to Beijing).

This field trip is hosted by the Qinghai Lake National Nature Reserve and CNIC.

Flights between Beijing and Xining

June 2, 2010: Beijing → Xining, CA1261 (11:45am departure in Beijing)
After arriving in Xining airport, a tour bus will take the participants to the Qinghai Lake (a 3-hour bus ride across the beautiful grasslands)

June 3, 2010: Site visits to Qinghai Lake, bird watch,

June 4, 2010: Xining → Beijing, CA1262 (3:40pm departure in Xining)

Hotel in Qinghai Lake

Bus

Field tours

Meals

Meetings and discussion in Qinghai Lake