LETTER

Effects of the 2022 extreme droughts on avian influenza transmission risk in Poyang Lake

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Dear Editor,

Climate change and extreme climate events (e.g., droughts, floods, heatwaves) have substantial negative impacts on landscapes, animals, and humans, which may further increase spillover and transmission risk of zoonotic infectious diseases.[1] For example, extreme droughts could result in a substantial loss of water-related habitats (open surface water bodies, natural wetlands, and rice paddies), which reduces the amount of food resources and shelters available to wild waterfowl, thus further affects migratory waterfowl in different ways (Figure 1A), including (1) weaker and less healthy wild waterfowl, (2) higher density of wild waterfowl in fewer and smaller patches of habitats, which increases contact rates, virus exchange, and transmission risk among waterfowl,[2] (3) movement of wild waterfowl to use other and nearby agricultural habitats, which increases contacts between poultry and waterfowl and spread of highly pathogenic avian influenza virus (AIV),[3,4] and (4) movement of wild waterfowl to other surface water bodies and natural wetlands beyond their normal ranges, which could potentially introduce AIV to new places.

Poyang Lake, the largest freshwater lake in China, provides critical wintering habitats for over 680,000 migratory waterfowl along the Eastern Asian-

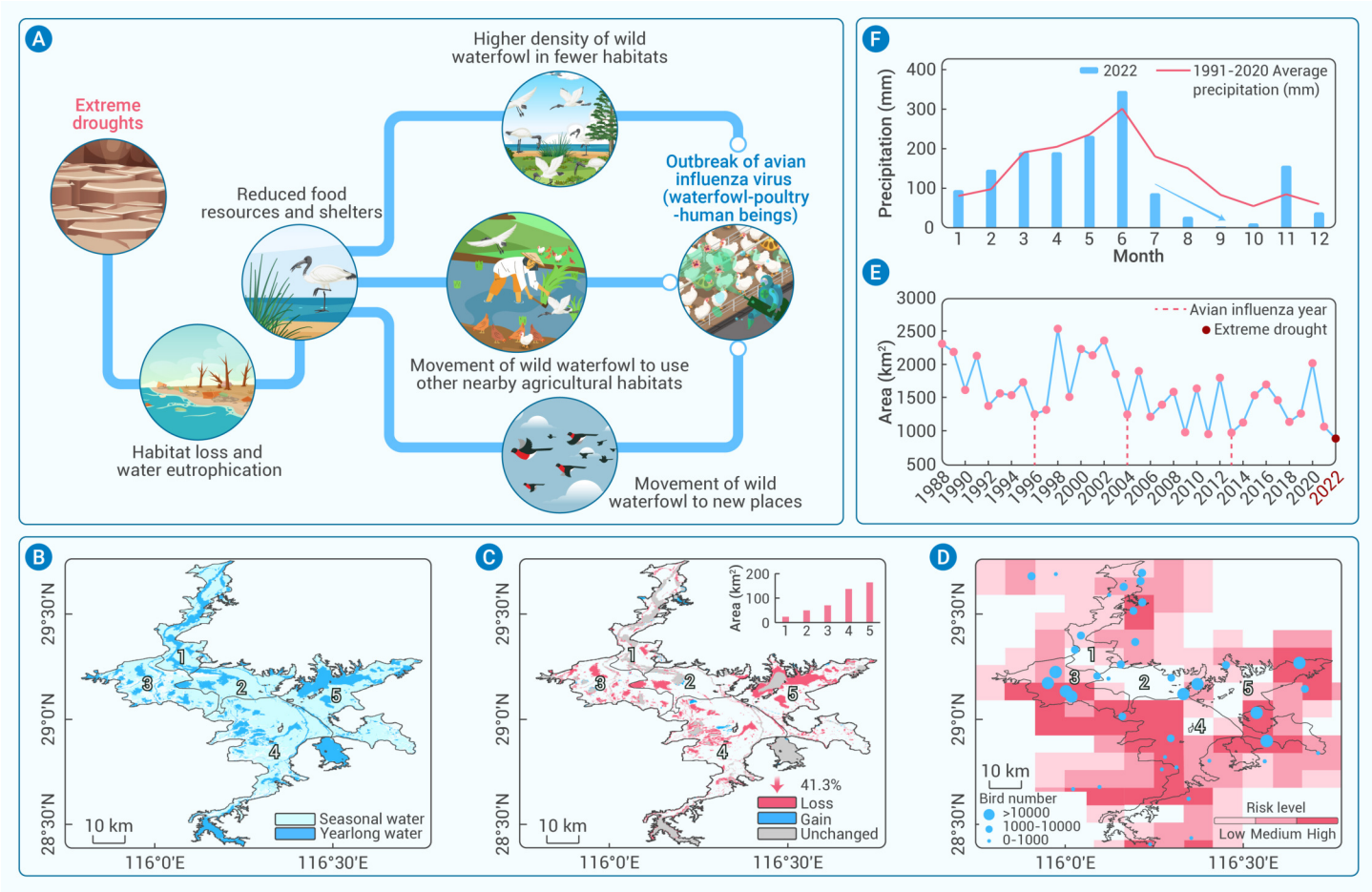

Figure 1. Extreme drought in 2022 and potential outbreak risk of avian influenza virus (AIV) in Poyang Lake, China (A) Schematic diagram that illustrates the effects of extreme droughts on AIV outbreak. (B) Distributions of yearlong and seasonal surface water bodies in 2021. (C) The changes (loss or gain) of those areas that were yearlong surface water bodies in 2021 by 12/2022. (D) Wild waterfowl numbers and risk levels of AIV outbreak. (E) Annual yearlong surface water areas of Poyang Lake from 1988 to 2022 and three AIV outbreak events. (F) Precipitation in 2022 and average precipitation during 1991-2020 by month in Jiangxi Province. Precipitation data was acquired from the Jiangxi Climate Bulletin in 2022.

Australasian Flyway. Since July 2022, it has been experiencing the most intense and longest drought since instrument records began in 1951. This situation has had severe impacts on aquatic vegetation, benthic macrofauna, and fish, which might pose formidable challenges for the migratory waterfowl that are going to winter here. Furthermore, the Poyang Lake area has an intensive poultry industry with more than 40 million domestic poultry in stock,

and it has been considered as one of the world's hotspots for spillover and transmission of H5N1 AIV.[5]

We generated the annual maps of surface water frequency (SWF, defined as the percentage of observations classified as surface water body to the total good-quality observations during a specific period) in Poyang Lake using all the Landsat imagery in 2021 and 2022 (last access in Google Earth Engine: 9 January 2023), and classified surface water into two major types based on the SWF of individual pixels: yearlong surface water (surface water presents all seasons, SWF ≥ 0.75) and seasonal surface water (0.05 ≤ SWF <0.75)[6] (Figure 1B). The yearlong surface water area (SWA_{year}) in 2021 was ~1,077 km^2 and the seasonal surface water area (SWA_{season}) in 2021 was 2,229 km^2. However, only ~632 km^2 of the SWA_{year} in 2021 remained to be identified as yearlong surface water in 2022, which indicates a loss of ~445 km^2 (41.3%) of the SWA_{year} area in 2022 (Figure 1C). This process of SWA loss in 2022 started in July and had not subsided by December, indicating the longest drought period in Poyang Lake (Figure 1E). To further illustrate the impacts of this extreme drought, we also generated the SWF maps over the three-month wet-season period (July, August, September) in 2021 and 2022, respectively. The SWA with SWF ≥ 0.75 was 3,167 km^2 in 2021 and 764.4 km^2 in 2022, indicating a loss of ~75.9% of the SWA during the wet season in 2022.

The yearlong surface water is usually determined by the surface water extent during the winter season,[6] coinciding with the migratory and wintering time of waterfowl, thus, the large loss of yearlong surface water area in Poyang Lake in 2022 could affect wintering migratory waterfowl in various ways, specifically (1) migratory waterfowl move to other places beyond the Poyang Lake, and (2) migratory waterfowl stay within the Poyang Lake over smaller habitats with higher waterfowl density. We investigated the potential spillover and transmission risk of AIV (high, medium, and low) by analyzing the abundance maps of wild waterfowl and duck in Poyang Lake (Figure 1D). Areas of high-risk of AIV spillover and transmission were considered to be those with higher densities of wild waterfowl and duck and closer distances between wild waterfowl and duck. The result showed that southwestern Poyang Lake had a higher AIV risk level, especially in southern Zone 3 and western Zone 4 as these regions had large numbers of wild waterfowl and duck. Eastern Zone 5 is another high-risk region because of the medium duck and high wild waterfowl numbers.

In retrospect, the yearlong surface water area in Poyang Lake varied greatly during 1988-2022 (Figure 1E). Literature research on the history of highly pathogenic avian influenza outbreaks reported three large AIV outbreak events in Poyang Lake in the years of 1996, 2004, and 2013.[4,5,7] We found that all these three years had very small amounts of SWA, indicating the potential linkage among extreme droughts, loss of surface water area, migratory waterfowl and AIV outbreaks in Poyang Lake. As hundreds of thousands of migratory waterfowl would winter in Poyang Lake, the situation in Poyang Lake is a major concern for the potential spillover and transmission risk of highly pathogenic avian influenza in the winter and following spring. The results from this study will raise awareness of the situation in the region and call for emergent preventative actions on the possible spillover and transmission risk of AIV.

The extreme drought in Poyang Lake in 2022 was mainly caused by the largely reduced rainfall and runoff in the Yangtze River Basin, which resulted from the atmospheric circulation anomaly, too short Meiyu period in summer, and the few landward typhoons[8] (Figure 1F). In addition, several human activities may also affect SWA and AIV outbreak risk levels in Poyang Lake. The Three Gorges Dam (TGD), the world's largest hydroelectric dam in upstream from the Poyang Lake, has been proved that its impoundment has significant linkage with the shrinkage of the Poyang Lake, especially the droughts in the autumn and winter.[6] In addition, intensive sand mining has resulted in a wider and deeper outflow channel for Poyang Lake, allowing it to drain quickly and reach a lower water level and increase the drought risk.[9] Even worse, large numbers of domestic ducks and geese are raised with little or no biosecurity surrounding Poyang Lake,[10] and the highly crowded conditions provide good opportunity for the emergence of novel AIV subtypes and spillover into wild bird populations.

The Chinese government has recognized the impacts of severe droughts on Poyang Lake and taken several measures to maintain critical habitats for wild waterfowl in Poyang Lake in 2022. Water-resource agencies have pumped more water into the critical wetlands of Poyang Lake, and the local government has paid farmers to create more "pop-up" wetlands in their post-harvested croplands. Food sources (e.g., sedge, prey fishes) for migratory birds have been added to the wetlands. All these measures certainly help reduce the impacts of droughts on migratory wild waterfowl. Additionally, more comprehensive efforts are urgently needed to maintain and restore wetland areas in drought years and reduce the contact between wild waterfowl and poultry. First, we should put more efforts on monitoring surface water and drought risks in summer and fall and assessing the long-term trend of surface water to provide recommendation for monitoring and early action. Second, we recommend expanding AIV surveillance in poultry, waterfowl, and the environment, improving the biosafety of poultry farms and carrying out large-scale vaccination for poultry in the Poyang Lake area. In addition, the countries along the Eastern Asian-Australasian Flyway should prepare and maintain AIV surveillance systems and improve analysis capabilities, and learn the AIV history from each other and then adopt coordinated measures in prevention, control, and intervention strategies for AIV. Finally, as current understanding of the impacts of climate change and extreme climate events on migratory waterfowl and AIV spillover and transmission remains very limited, international collaboration in coordinated research and funding support is urgently needed to predict, prevent and control the spillover, transmission, and pandemic of highly pathogenic AIV.

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DECLARATION OF INTERESTS

The authors declare no competing interests.