WOAH Collaborative Centre Reports Activities 2023

Activities in 2023

This report has been submitted : 27 juin 2024 20:45

Centre Information

Title of WOAH Collaborating Centre	Research on Emerging Avian Diseases
Address of WOAH Collaborating Centre	Southeast Poultry Research Laboratory, U.S. National Poultry Research Center, Agricultural Research Service, U.S. Department of Agriculture, 934 College Station Rd, Athen, GA 30605, USA
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Name Director of Institute (Responsible Official):	David L. Suarez
Name (including Title and Position) of Head of the Collaborating Centre (WOAH Contact Point):	David L. Suarez Research Leader Exotic and Emerging Avian Viral Disease Research Unit
Name of the writer:	David L. Suarez

TOR1 AND 2: SERVICES PROVIDED

1. Activities as a centre of research, expertise, standardisation and dissemination of techniques within the remit of the mandate given by WOAH

Category	Title of activity	Scope
Disease control (true)	Avian influenza, research	• The infectivity and transmissibility of a 2022 North American H5N1 highly pathogenic avian influenza virus (HPAIV) varies between chickens and turkeys. HPAIV's of the clade 2.3.4.4 goose/Guangdong/1996 H5 lineage remain a major threat to poultry because wild birds carry the virus and contaminate the environment. H5N1 HPAIV was first detected in December 2021 in South Carolina, U.S., and since then, then virus has infected a great number of wild and domestic birds. ARS scientists in Athens, GA, evaluated the pathobiology in chickens and turkeys of an early 2022 U.S. H5N1 isolate. Differences in clinical signs, mean death times, and virus transmissibility were found between chickens and turkeys. Although the amount of virus required to infect both species was low compared to similar clade 2.3.4.4 viruses, turkeys transmitted the virus better than chickens because it took longer for them to get sick even when they were excreting virus, which increased the virus shedding period and facilitated transmission. These differences affect the epidemiology of the H5N1 HPAIV and will inform the development of species strategies to prevent,

		diagnose, and mitigate HPAI outbreaks.
Epidemiology, surveillance, risk assessment, (true)	Newcastle disease virus, research	• Diverse Newcastle disease viruses circulates in wild and synanthropic birds in Ukraine. Newcastle disease virus (NDV) infects a wide range of bird species worldwide and is of importance to the poultry industry. Although certain virus genotypes are clearly associated with wild bird species, the role of those species in the movement of viruses and the migratory routes they follow is still unclear. ARS scientists in Athens, Georgia, analyzed 21,924 samples collected from wild and synanthropic birds in Ukraine from 2006 to 2015 and identified nineteen NDV sequences. Sequence analysis showed that synanthropic birds may play a role in viral transmission from vaccinated poultry to wild birds, which may also lead to the further spreading of vaccine viruses into other regions during wild bird migration. The study also highlights the possible exchange of NDV strains between wild waterfowl from the Azov-Black Sea region of Ukraine and waterfowl from different continents, including Europe, Asia, and Africa.
Training, capacity building (true)	Avian diseases, training	We support the training of multiple postdoctoral researchers and visiting scientist through research being conducted in the laboratory.
Zoonoses (true)	Avian influenza, research	• Comparative analysis of polymerase (PB2) gene of H5 avian influenza virus (AIV) isolated from birds and mammals demonstrates preferential differences in sequence based on species. AIVs do not normally infect mammals, however, recent outbreaks have demonstrated the ability to transmit to other species. In these studies, scientists in Athens, GA compare known genetic markers of adaption in the PB2 gene at position 627. It was demonstrated that recent isolates of H5 AIV from mammalian species have a higher conversion of glutamic acid to lysine compared to bird isolates. In addition, the >97% of all avian species demonstrated a glutamic acid at position 627 regardless of the H5 lineage examined. These studies broaden our understanding of AIV adaption in other species.
Wildlife (true)	Avian influenza, research	• Mallards are highly susceptible to, and shed high quantities of the 2022 North American H5N1 highly pathogenic avian influenza virus (HPAIV). HPAIV's of the clade 2.3.4.4 goose/Guangdong/1996 H5 lineage continue to be a problem in poultry and wild birds in much of the world. The recent incursion of a H5N1 clade 2.3.4.4b HPAIV from this lineage into North America has resulted in widespread outbreaks in poultry and consistent detections of the virus across diverse families of wild birds and occasionally mammals. ARS scientists in Athens, GA, characterized the pathobiology of this virus in young mallards (Anas platyrhynchos), which are a primary reservoir of avian influenza viruses in the wild and are closely related to domestic ducks (i.e., Pekin ducks). The infectious dose was extremely low and 100% transmission was observed. No clinical signs were seen in most ducks; however, some of the observed clinical signs, such as neurological signs, would likely be fatal in the wild, but may not occur with older ducks. The mallards shed virus by both the oral and cloacal routes and 65% of the ducks

		where still shedding virus cloacally through 14 days post-exposure. Based on the high transmissibility, high virus shed titers, and mild-tomoderate disease, mallards could serve as efficient reservoirs to amplify and disseminate recent North American clade 2.3.4.4b viruses.
Avian diseases (true)	Newcastle disease virus, research	• Low virulent Newcastle disease virus with unique amino acid signature found in virulent virus identified. Newcastle disease is one of the most important infectious diseases of poultry because of its potential for devastating loses. Not all avian Orthoavulavirus-1 (AOAV-1) cause Newcastle disease but the virus has ability to change their genetic makeup and become more virulent while adapting to new hosts and environments. ARS scientists in Athens, Georgia, identified a low virulent AOAV-1 isolate with a unique amino acid signature that is found in virulent viruses. Although the study confirmed that the virus is low virulent, it is important to monitor if viruses with similar genetic makeup is circulating in poultry and any additional changes are occurring toward more virulent form. It is also important to note that the new virus was detected by official diagnostic test that specifically detect virulent AOAV-1. Thus, in addition to concern for potential pathogenic shift of the virus through additional genetic change, the finding warrants increased awareness of diagnosticians of potential false positive tests.
Diagnosis, biotechnology and laboratory (true)	Avian diseases, research	• Non-targeted next generation sequencing (NGS) is widely applied to identify the diversity of pathogens in field samples. However, abundance of host RNA (especially rRNA) and other environmental nucleic acids can reduce the abundance of pathogen specific reads of interest, reduce depth of coverage and increase surveillance costs. ARS researchers in Athens, Georgia, have progressively optimized the multistep workflow for host depletion and demonstrated that replacing the kit specific buffer with a commercially sourced alternative buffer yields similar or better data at a significant cost advantage. In addition, ARS researchers further optimized the non-target RNA depletion by testing multiple DNA degrading conditions and identified a replacement enzyme that significantly improved the efficiency of target RNA preparation and yields of pathogen specific sequencing reads.
Vaccines (true)	Avian Influenza, research	• Vaccines currently available in the U.S. protect chickens against recent strains of highly pathogenic avian influenza virus (HPAIV). Vaccination is being considered to help control HPAIV spread in poultry due to an ongoing outbreak of HPAI in the U.S. If vaccination is implemented, surveillance programs will need to be modified to identify vaccinated birds that have also been infected with virus (DIVA-VI). ARS scientists in Athens, GA tested two U.S. licensed commercial vaccines and two in-house produced vaccines for their effectiveness against the current U.S. HPAIV's and evaluated two tests for DIVA-VI. All four vaccines provided protection against death and disease but varied in how well they reduced virus shedding by chickens. Both DIVA-VI tests could identify infected birds seven days after infection, however there was variation in sensitivity among the vaccines and tests. This study has confirmed the

		efficacy of several vaccines and associated DIVA-VI tests that could be used in U.S. poultry. The data are critical for establishing vaccination and associated surveillance programs that will meet the disease control and regulatory needs of government and industry stakeholders.
Vaccines (true)	Vectored vaccines for poultry, research	• Multivalent vectored vaccines are efficacious against viral infections in poultry. Vaccines are an essential tool for the control of viral infections in domestic birds. ARS scientists in Athens, GA, in collaboration with scientists at the University of Georgia generated recombinant vector herpesvirus of turkeys (vHVT) vaccines expressing computationally optimized broadly reactive antigens (a method called "COBRA") of H5 avian influenza virus (AIV) alone in a herpes virus of turkeys (rHVT) vector (vHVT-AI) or in combination with virus protein 2of infectious bursal disease virus (IBDV) (vHVT-IBD-AI) or fusion protein of Newcastle disease virus (NDV) (vHVT-ND-AI). In vaccinated chickens, all three vaccines provided 90-100% clinical protection against three divergent clades of high pathogenicity avian influenza viruses (HPAIV), and significantly decreased both the number of birds shedding virus and the quantities of virus excreted by the oral route. The multivalent vHVT-IBD-AI and vHVT-ND-AI vaccines provided 100% clinical protection against IBDVs and NDV, respectively. These findings demonstrate that multivalent HVT vector vaccines were efficacious for simultaneous.
Vaccines (true)	Newcastle disease virus, research	• Improving the safety of live vaccines to be applied to chicken embryos inside eggs (in ovo). Due to the extent of the current HPAI outbreak in the U.S., there has been serious consideration for the use of vaccines as a component of control programs. In poultry production, vaccination of chicken embryos inside eggs (in ovo) is cost-effective method and can protect chicks from disease early in their life. However, live vaccine which are proven to be effective in older chickens may not be safe when administered in ovo. ARS scientists in Athens, Georgia, in collaboration with researchers at The Ohio State University, incorporated genetic modifications in a live vaccine virus to improve safety for use in ovo while maintaining its protective efficacy. The ability to expand the vaccines that can be applied in ovo, is instrumental in developing practical and efficient vaccines for HPAIV or other viruses in poultry.

TOR3: HARMONISATION OF STANDARDS

2. Proposal or development of any procedure that will facilitate harmonisation of international regulations applicable to the main fucus area for which you were designated

Proposal title	Scope/Content	Applicable area

3. In exercising your activities, have you identified any regulatory research needs* relevant for WOAH?

No

4. Did your Collaborating Centre maintain a network with other WOAH Collaborating Centres (CC), Reference Laboratories (RL), or organisations designated for the same specialty, to coordinate scientific and technical studies?

Yes

Name of WOAH CC/RL/other organisation(s)	Location	Region of networking Centre	Purpose
Diagnosis of Animal Diseases in the Americas USDA, APHIS, Veterinary Services, P.O. Box 844, Ames, Iowa 50010	USA	Americas	Coordinate diagnostics to improve detection of highly pathogenic avian influenza, Newcastle disease virus adn avian metapneumovirus

TOR4 AND 5: NETWORKING AND COLLABORATION

5. Did your Collaborating Centre maintain a network with other WOAH Collaborating Centres, Reference laboratories, or organisations in other disciplines, to coordinate scientific and technical studies?

Yes

Name of WOAH CC/RL/other organisation(s)	Location	Region of networking Centre	Purpose
National Reference Laboratories for Avian Influenza and Newcastle Disease of European Union Member States	Italy	Europe	Share research on avian influenza and Newcastle diagnostics and control
Roslin Institute at the University of Edinburgh	United Kingdom	Europe	Evolution of avian influenza viruses
WOAH Reference Laboratories for avian influenza	Canada, Italy, USA	Americas Europe	Multilateral sharing of experimental and diagnostic data on 2.3.4.4b HPAI to improve diagnosis and reduce duplication of research studies
University of Georgia	USA	Americas	Development of modified live vaccines for protection of poultry against high and low pathogenic avian influenza virus
Centers for Disease Control and Prevention Influenza Division, NCIRD	USA	Americas	Collaborative studies on highly pathogenic avian influenza with zoonotic potential

TOR6: EXPERT CONSULTANTS

6. Did your Collaborating Centre place expert consultants at the disposal of WOAH?

Yes

NAME OF EXPERT	KIND OF CONSULTANCY	SUBJECT

David Suarez	Scientific	OFFLU network expert on avian influenza, Newcastle disease virus
Erica Spackman	Scientific	OFFLU network expert on avian influenza
Darrell Kapczynski	Scientific	Avian influenza
Chang-Won Lee	Scientific	Avian influenza and Newcastle disease

TOR7: SCIENTIFIC AND TECHNICAL TRAINING

7. Did your Collaborating Centre provide advice/services to requests from Members in your main focus area?

Yes

Provided sequencing support for Colombia and Uruguay for H5N1 Highly pathogenic avian influenza.
Provided analysis of available vaccines to Peru in their consideration for use of vaccines

8. Did your Collaborating Centre provide scientific and technical training, within the remit of the mandate given by WOAH, to personnel from WOAH Members?

Yes

a) Technical visit : 0

b) Seminars : 0

c) Hands-on training courses: 0

d) Internships (>1 month) : 5

TYPE OF TECHNICAL TRAINING PROVIDED (A, B, C OR D)	CONTENT	COUNTRY OF ORIGIN OF THE EXPERT(S) PROVIDED WITH TRAINING	NO. PARTICIPANTS FROM THE CORRESPONDING COUNTRY
D	Serologic characterization of vaccinated birds for DIVA surveillance	Egypt	1
D	Diagnosis, epidemiology, control (including vaccines and pathobiology of avian influenza and Newcastle disease virus	South Korea	2
D	Sequencing and bioinformatic analysis of avian influenza and other viral diseases of poultry	Ukraine	1
D	Sequencing and bioinformatic analysis of avian influenza and other viral diseases of poultry	Kenya	1

TOR8: SCIENTIFIC MEETINGS

9. Did your Collaborating Centre organise or participate in the organisation of scientific meetings related to your main focus area on behalf of WOAH?

No

TOR9: DATA AND INFORMATION DISSEMINATION

10. Publication and dissemination of any information within the remit of the mandate given by WOAH that may be useful to Members of WOAH

a) Articles published in peer-reviewed journals:

25

1. Spackman, E., D. L. Suarez, C.-W. Lee, Mary J. Pantin-Jackwood, Scott A. Lee, S. Youk, S. Ibrahim. 2023. Efficacy of Inactivated and RNA Particle Vaccines in Chickens Against Clade 2.3.4.4b H5 Highly Pathogenic Avian Influenza in North America. Vaccine 41:7369–7376. DOI:10.1016/j.vaccine.2023.10.070

2. Youk, S, M. K Torchetti; K. Lantz; J. B Lenoch; M. L. Killian; C. Leyson; S. N Bevins; K. E Dilione; H. S Ip; D. E Stallknecht; R. E Poulson; D. L Suarez; D. E Swayne, M.P. Jackwood. 2023. H5N1 highly pathogenic avian influenza clade 2.3.4.4b in wild and domestic birds: introductions into the United States and reassortments, December 2021-April 2022. Virology.15(11):2273. doi: 10.3390/v15112273.

3. Kapczynski, D. R., K. Chrzastek, R. Shanmugasundaram, A. Zsak, K. Segovia, H. Sellers, D. L. Suarez. 2023. Efficacy of recombinant H5 vaccines delivered in ovo or day of age in commercial broilers against the 2015 U.S. H5N2 clade 2.3.4.4c highly pathogenic avian influenza virus. Virology Journal. 20:298. DOI: 10.1186/s12985-023-02254-1

4. Roberts, E., C. Allen, R. Brennen, A. Swartz, B. Dines, F. Cigel, M. L. Killian, B. Crossley, D. L. Suarez, M. Torchetti, S. Slavinsky, K. Toohey-Kurth, S. Newbury. Discovery of Influenza A(H7N2) in a cat: a case report. 2023. Journal of Shelter Medicine and Community Animal Health. 2: 61. http://dx.doi.org/10.56771/jsmcah.v2.61

5. Kariithi, H M., J. D. Volkening, G. H. Chiwanga, I. V. Goraichuk, T. L. Olivier, P. L. M. Msoffe and D. L. Suarez. 2023. Virulent Newcastle Disease Virus Genotypes V.3, VII.2 and XIII.1.1 and their Coinfections with Infectious Bronchitis Viruses and other Avian Pathogens in Backyard Chickens in Tanzania. Frontiers of Veterinary Medicine. 10:2023. https://doi.org/10.3389/fvets.2023.1272402

6. Bakre, A.B., H. Kariithi. And D.L. Suarez. 2023. Alternative probe hybridization buffers for target RNA depletion and viral sequence recovery in NGS for poultry samples. Journal of Virological Methods. 321 (2023) 114793. https://doi.org/10.1016/j.jviromet.2023.114793

7. Kariithi, H. M. D. L. Suarez, J. F. Davis, L. Dufour-Zavala, T. L. Olivier, D. Williams-Coplin, A. Bakre, C. Lee. 2023. Genome Sequencing and Characterization of an Avian Orthoavulavirus-1 VG/GA-like Isolate with a Unique Fusion Cleavage Site Motif. Avian Diseases. 67:33–41, https://doi.org/10.1637/aviandiseases-D-22-00064

8. Goraichuk, I.V., D. Muzyka , O. Gaidash , A. Gerilovych , B. Stegniy , M. Pantin-Jackwood, P J Miller, C L Afonso, D. L. Suarez. 2023. Complete Genome Sequence of an Avian Orthoavulavirus 13 strain detected in Ukraine. Microbiology Resource Announcements. 12:06. 10.1128/mra.00197-23.

9. Ghorbani, A., Ngunjiri, J.M., Abundo, M.C., Pantin Jackwood, M.J., Kenney, S.P., Lee, C.W. 2023. Development of in ovo-compatible NS1-truncated live attenuated influenza vaccines by modulation of hemagglutinin cleavage and polymerase acidic frameshifting sites. Vaccine. 41(11):1848-1858. https://doi.org/10.1016/j.vaccine.2023.01.018.

10. Criado, M.F., Kassa, A., Bertran, K., Kwon, J., Sa E Silva, M., Killmaster, L.F., Ross, T.M., Mebatsion, T., Swayne, D.E. 2023. Efficacy of multivalent recombinant herpesvirus of turkey vaccines against high pathogenicity avian influenza, infectious bursal disease, and Newcastle disease viruses. Vaccine. 41(18):2893-2904. https://doi.org/10.1016/j.vaccine.2023.03.055.

11. Kwon, J., Bertran, K., Lee, D., Criado, M.F., Killmaster, L.F., Pantin Jackwood, M.J.,Swayne, D.E. 2023. Diverse infectivity, transmissibility and pathobiology of clade 2.3.4.4 H5Nx highly pathogenic avian influenza viruses in chickens. Emerging Microbes & Infections. 12:2218945. https://doi.org/10.1080/22221751.2023.2218945.

12. Pantin-Jackwood MJ, Spackman E, Leyson C, Youk S, Lee SA, Moon LM, Torchetti MK, Killian ML, Lenoch JB, Kapczynski DR, Swayne DE, Suarez DL. Pathogenicity in Chickens and Turkeys of a 2021 United States H5N1 Highly Pathogenic Avian Influenza Clade 2.3.4.4b Wild Bird Virus Compared to Two Previous H5N8 Clade 2.3.4.4 Viruses.Viruses. 2023 Nov 18;15(11):2273. doi: 10.3390/v15112273.

13. Spackman E, Pantin-Jackwood MJ, Lee SA, Prosser D.The pathogenesis of a 2022 North American highly pathogenic clade 2.3.4.4b H5N1 avian influenza virus in mallards (Anas platyrhynchos). Avian Pathol. 2023 Jun;52(3):219-228. doi: 10.1080/03079457.2023.2196258.

14. Goraichuk IV, Gerilovych A, Bolotin V, Solodiankin O, Dimitrov KM, Rula O, Muzyka N, Mezinov O, Stegniy B, Kolesnyk O, Pantin-Jackwood MJ, Miller PJ, Afonso CL, Muzyka D. Genetic diversity of Newcastle disease viruses circulating in wild and synanthropic birds in Ukraine between 2006 and 2015. Front Vet Sci. 2023 Jan 19;10:1026296. doi: 10.3389/fvets.2023.1026296.

15. Mo J, Spackman E, Swayne DE. Prediction of highly pathogenic avian influenza vaccine efficacy in chickens by comparison of in vitro and in vivo data: A meta-analysis and systematic review. Vaccine. 2023 Aug 31;41(38):5507-5517. doi: 10.1016/j.vaccine.2023.07.076

16. Briggs K, Kapczynski DR.Comparative analysis of PB2 residue 627E/K/V in H5 subtypes of avian influenza viruses isolated from birds and mammals. Front Vet Sci. 2023 Sep 1;10:1250952. doi: 10.3389/fvets.2023.1250952

17. Bakre A, Kariithi HM, Suarez DL. 2023. Alternative probe hybridization buffers for target RNA depletion and viral sequence recovery in NGS for poultry samples. J Virol Methods. 321:114793. https://doi.org/ 10.1016/j.jviromet.2023.114793.

18. Goraichuk IV, Msoffe PLM, Chiwanga GH, Dimitrov KM, Afonso CL, Suarez DL. 2023. Complete genome sequence of seven virulent Newcastle disease virus isolates of sub-genotype XIII.1.1 from Tanzania. Microbiol Resour Announc. 12(10):e0040523. https://doi.org/10.1128/MRA.00405-23.

19. Lee, C.W., Mahesh, K.C., Ngunjiri, J.M., Ghorbani, A., Lee, K. 2023. TLR3 and MDA5 knockout DF-1 cells enhance replication of avian orthoavulavirus 1. Avian Diseases. 67(1):94-101. https://doi.org/10.1637/aviandiseases-D-22-00065.

20. Briggs, K., R. Sweeney, D. S. Blehert, E. Spackman, D. L. Suarez, D. R. Kapczynski. 2023. SARS-CoV-2 utilization of ACE2 from different bat species allows for virus entry and replication in vitro. Virology. 586: 122 – 129. 10.1016/j.virol.2023.07.002.

21. Kariithi, H. M., J. D. Volkening, G H. Chiwanga, I V. Goraichuk, P. L. M. Msoffe and D. L. Suarez. 2023. Molecular Characterization of Complete Genome Sequence of an Avian Coronavirus Identified in a Backyard Chicken from Tanzania. Genes:14, 1852. https://doi.org/10.3390/genes14101852

22. Kariithi, H. M. D. L. Suarez, J. F. Davis, L. Dufour-Zavala, T. L. Olivier, D. Williams-Coplin, A. Bakre, C. Lee. 2023. Genome Sequencing and Characterization of an Avian Orthoavulavirus-1 VG/GA-like Isolate with a Unique Fusion Cleavage Site Motif. Avian Diseases. 67:33–41, https://doi.org/10.1637/aviandiseases-D-22-00064

23. Kariithi, H. M., J. D. Volkening, V. V. Alves, J. L. Reis-Cunha, L. C. R. Veloso Arantes, F. S. Fernando, T. Fernandes Filho, N. Rodrigo da Silva Martins, S. Lemiere, O. C. de Freitas Neto, E. L. Decanini, C. L. Afonso, D. L. Suarez. 2023. Complete genome sequences of avian metapneumovirus subtype B vaccine strains from Brazil. Accepted Microbiology Resource Announcements. 12:6. https://doi.org/10.1128/mra.00235-23.

24. Kariithi, H. M., J. D. Volkening, G. H. Chiwanga, M. J. Pantin-Jackwood, P. L. M. Msoffe, and D. L. Suarez. 2023. Genome Sequences and Characterization of Chicken Astrovirus and Avian Nephritis Virus from Tanzanian Live Bird Markets. Viruses: 15(6), 1247; https://doi.org/10.3390/v15061247

25. Kariithi, H. M. J. D. Volkening, I. V. Goraichuk, L. O. Ateya, D. Williams-Coplin, T. L. Olivier, Y. S. Binepal , C. L. Afonso, and D. L. Suarez. 2023. Unique Variants of Avian Coronaviruses from Indigenous Chickens in Kenya. Viruses 2023, 15(2), 264; https://doi.org/10.3390/v15020264

b) International conferences:

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PROCINORTE Animal Health Task Force Annual Meeting Mexico City, MX 2023 June 8th, 2023.

Global Framework for the Progressive Control of Transboundary Animal Diseases. Virtual Meeting March 3rd, 2023.

29th Annual Meeting of the National Reference Laboratories for Avian Influenza and Newcastle Disease of European Union Member States, 2-3 October 2023

XXII World Veterinary Poultry Association (WVPA) Congress, Verona September 4-8, 2023

c) National conferences:
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American Association of Avian Pathologists, Ponte Vedra Florida, June 10-14, 2023
Poultry Tech Summit, Atlanta, GA November 7-8th, 2023.
Poultry Science Association Annual Meeting, Philadelphia, PA July 11-14, 2023.
United States Animal Health Association, National Harbor, MD October 12-18th, 2023
Veterinary Scholars Symposium, San Juan Puerto Rico, August 3-5, 2023.
Centers of Excellence for Influenza Research and Response Annual meeting, Baltimore, MD 28-31, 2023.
General Conference Committee of the National Poultry Improvement Plan, Columbus, OH June 29th, 2023
National Turkey Federation Annual Meeting, Palm Springs, CA Feb 22-25, 2023

d) Other (Provide website address or link to appropriate information):

11. What have you done in the past year to advance your area of focus, e.g. updated technology?
Research to improve the sensititvity of random amplification next generation sequencing is ongoing.

12. Additional comments regarding your report: