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DZĪVĪBAS ZINĀTŅU UN TEHNOLOĢIJU INSTITŪTS

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MĀRTIŅŠ SERŽANTS

ĀFRIKAS CŪKU MĒRA IZPLATĪBAS UN TĀ APKAROŠANAS PASĀKUMU IETEKME UZ MEŽA CŪKU POPULĀCIJU LATVIJĀ

Promocijas darbs

zinātniskā doktora grāda (Ph. D.) Dabaszinātnēs iegūšanai

(Bioloģijas nozarē, Ekoloģijas apakšnozarē)

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DARBĀ LIETOTĀS ABREVIATŪRAS UN AKRONĪMI

ĀCM	Āfrikas cūku mēris
ĀCMV	Āfrikas cūku mēra vīruss
BIOR	Pārtikas drošības, dzīvnieku veselības un vides zinātniskā institūta "BIOR"
DIVA	Vakcinētu un inficētu dzīvnieku diferencēšanas pieeja
DNS	dezoksiribonukleīnskābe
ELISA	Enzīmsaistītais imūnsorbcijas tests
IPT	Imūnperoksidāzes tests
PCR	Polimerāzes ķēdes reakcija
Piem.	piemēram
PVD	Pārtikas un veterinārais dienests
VMD	Valsts meža dienests
WAHIS	WOAH globālā dzīvnieku slimību ziņošanas un uzraudzības datubāze
WOAH	Pasaules Dzīvnieku veselības organizācija

PUBLIKĀCIJU SARAKSTS

Promocijas darbs ir izstrādāts kā tematiski vienota zinātnisko publikāciju kopa, kas disertācijas tekstā ir norādītas ar romiešu cipariem. Oriģinālie raksti ir publicēti ar izdevēju atļaujām.

I. E. Oļševskis, V. Guberti, **M. Seržants**, J. Westergaard, C. Gallardo, I. Rodze, K. Depner, 2016. African swine fever virus introduction into the EU in 2014: Experience of Latvia," *Research in Veterinary Science*, vol. 105, pp. 28-30. http://dx.doi.org/10.1016/j.rvsc.2016.01.006 (IF =2.4, Q1)

II. Schulz, K. Oļševskis, E., Staubach, C., Lamberga, K., **Seržants, M.**, Cvetkova S., Conraths, F.J & Sauter-Louis, C. 2019. Epidemiological evaluation of Latvian control measures for African swine fever in wild boar on the basis of surveillance data. *Sci Rep* 9, 4189. https://doi.org/10.1038/s41598-019-40962-3 (IF= 4.996, Q1)

III. Oļševskis, E, Schulz, K, Staubach, **Seržants, M**., Lamberga, K., Pūle, D., Ozoliņš, J., Conraths, F.J. and Sauter-Louis, 2020. C. African swine fever in Latvian wild boar—A step closer to elimination. *Transbound Emerg Dis*. 67: 2615–2629. https://doi.org/10.1111/tbed.13611 (IF= 4.521, Q1)

IV. Urner, N., **Seržants**, M., Užule, M., Sauter-Louis, C., Staubach, C., Lamberga, K., E. Oļševskis., Conraths, F.J., Schulz, K., 2021. Hunters' view on the control of African swine fever in wild boar. A participatory st udy in Latvia, *Preventive Veterinary Medicine,* 186 (2021) 105229 https://doi.org/10.1016/j.prevetmed.2020.105229 (IF= 3.372, Q1)

Autora ieguldījums publikāciju tapšanā: autoru pieminēšanas kārtība publikācijās aptuveni ataino viņu ieguldījumu pētījumu veikšanā.

Autors piedalījies pētījumu konceptuālajā izstrādē, formulējot pētījuma ideju un definējot darba uzdevumus, kā arī metodoloģijas plānošanā un praktiskajā īstenošanā, tostarp nodrošinot sadarbību ar medību tiesību lietotājiem un citiem iesaistītajiem partneriem. Autora ieguldījums ietver datu iegūšanu, apkopošanu un sistematizēšanu, to statistisko un epidemioloģisko analīzi, kā arī rezultātu interpretāciju un zinātnisko publikāciju sagatavošanu.

INFORMĀCIJA PAR PUBLIKĀCIJĀM UN ZINĀTNISKI PĒTNIECISKO DARBU

Zinātniskie raksti starptautiskajos žurnālos un konferenču krājums:

1. Lamberga, K., Viltrop, A., Nurmoja, I., Masiulis, M., Bušauskas, P., Oļševskis, E., **Seržants, M**., Laddomada, A., Ardelean, F., & Depner, K. (2024). The Effectiveness of Protection and Surveillance Zones in Detecting Further African Swine Fever Outbreaks in Domestic Pigs—Experience of the Baltic States. *Viruses*, 16(3), 334. https://doi.org/10.3390/v16030334
2. Rogoll, L., Schulz, K., Staubach, C., Oļševskis. E., **Seržants, M**., Lamberga., Conraths, Sauter-Louis, C. Identification of predilection sites for wild boar carcass search based on spatial analysis of Latvian ASF surveillance data. *Sci Rep* 14, 382 (2024). https://doi.org/10.1038/s41598-023-50477-7
3. Robardet, E., Zdravkova, A., Ilieva, D., Hakmann, E., Georgopoulou, I., Tasioudi, K., Nokireki, T., Isomursu, M., Lohman Jankovic, I., Lojkic, I., **Serzants, M**., Zommere, Z., Masiulis, M., Jaceviciene, I., Vuta, V., Wasniewski, M., & Dilaveris, D. (2024). Retrospective analysis of sero-prevalence and bait uptake estimations in foxes after oral rabies vaccination programmes at European level: Lessons learned and paths forward. *Veterinary Microbiology*, 288, 109917. https://doi.org/10.1016/j.vetmic.2023.109917
4. Oļševskis, E., Masiulis, M., **Seržants, M**., Lamberga, K., Šteingolde, Ž., Krivko, L., Cvetkova, S., Buitkuvien˙e, J., Pilevičiene, S., Zani, L., Denzin, N., and Depner., K. Do Seropositive Wild Boars Pose a Risk for the Spread of African Swine Fever? Analysis of Field Data from Latvia and Lithuania. *Pathogens* 2023, 12, 723. https://doi.org/10.3390/pathogens12050723
5. Richter, M., Schulz, K., Elflein, T., Achterberg, J., Oļševskis, E., **Seržants, M.,** Lamberga, K., Conraths, F. J., & Sauter-Louis, C. (2023). The first eighteen months of African swine fever in wild boar in Saxony, Germany and Latvia—A comparison. *Pathogens*, 12(1), 87. https://doi.org/10.3390/pathogens12010087
6. Schulz, K.; Oļševskis, E.; Viltrop, A.; Masiulis, M.; Staubach, C.; Nurmoja, I.; Lamberga, K.; **Seržants, M**.; Malakauskas, A.; Conraths, F.J.; Sauter-Louis, C. Eight Years of African Swine Fever in the Baltic States: Epidemiological Reflections. *Pathogens* 2022, 11, 711. https://doi.org/10.3390/pathogens11060711
7. Lamberga, K.; Ardelean, F.; Blome, S.; Busauskas, P.; Djuric, B.; Globig, A.; Guberti, V.; Miteva, A.; Oļševskis, E.; **Seržants, M**.; Viltrop, A.; Zani, L.; Zdravkova, A.; Depner, K. African Swine Fever Outbreak Investigations—The Significance of Disease-Related

Anecdotal Information Coming from Laypersons. *Pathogens* 2022, 11, 702. https://doi.org/10.3390/pathogens11060702

8. Lamberga, K., Depner, K., Zani, L., Oļševskis, E., **Seržants, M**., Ansonska, S., Šteingolde, Ž., Bērziņš, A., Viltrop, A., Blome, S., & Globig, A. (2022). A practical guide for strategic and efficient sampling in African swine fever–affected pig farms. *Transboundary and Emerging Diseases,* 69, e2408–e2417. https://doi.org/10.1111/tbed.14582
9. Urner, N., **Seržants, M**., Užule, M., Sauter-Louis, C., Staubach, C., Lamberga, K., Oļševskis, E., Conraths, F. J., & Schulz, K. (2021). Hunters' view on the control of African swine fever in wild boar: A participatory study in Latvia. *Preventive Veterinary Medicine*, 186, 105229. https://doi.org/10.1016/j.prevetmed.2020.105229
10. Oļševskis, E., Schulz, K., Staubach, C., **Seržants, M**., Lamberga, K., Pūle, D., Ozoliņš, J., Conraths, F. J., & Sauter-Louis, C. (2020). African swine fever in Latvian wild boar—A step closer to elimination. *Transboundary and Emerging Diseases*, 67(6), 2615–2629. https://doi.org/10.1111/tbed.13611
11. Lamberga, K., Oļševskis, E., **Seržants, M**., Bērziņš, A., Viltrop, A., & Depner, K. (2020). African swine fever in two large commercial pig farms in Latvia—Estimation of the high-risk period and virus spread within the farm. *Veterinary Sciences*, 7(3), 105. https://doi.org/10.3390/vetsci7030105
12. Schulz, K., Oļševskis, E., Staubach, C., Lamberga, K., **Seržants, M**., Cvetkova, S., Conraths, F. J., & Sauter-Louis, C. (2019). Epidemiological evaluation of Latvian control measures for African swine fever in wild boar on the basis of surveillance data. *Scientific Reports*, 9, 4189. https://doi.org/10.1038/s41598-019-40962-3
13. Lamberga, K., **Seržants, M**., & Oļševskis, E. (2018). African swine fever outbreak investigations in a large commercial pig farm in Latvia: A case report. *Berliner und Münchener Tierärztliche Wochenschrift*. https://doi.org/10.2376/0005-9366-18031
14. Oļševskis, E., Guberti, V., **Seržants, M**., Westergaard, J., Gallardo, C., Rodze, I., & Depner, K. (2016). African swine fever virus introduction into the EU in 2014: Experience of Latvia. *Research in Veterinary Science*, 105, 28–30. https://doi.org/10.1016/j.rvsc.2016.01.006

Pētījumu rezultātu aprobācija starptautiskās zinātniskās konferencēs:

1. Ozoliņš, J., **Seržants, M**., Oļševskis, E., Baumanis, J., Howlett, S. J., & Lūsis, V. (2016, September 10–21). Shaping the population sex-age structure for the control of wild boar in Latvia in the context of African swine fever. In The International Conference "Ungulates

in a changing world – consequences for population dynamics, migration and management" (p. 29). Krasny Bor, Belarus.

2. Lamberga, K., **Seržants, M**., Oļševskis, E., Schulz, K., & Depner, K. (2018, March 21–23). Epidemiological investigations in a large commercial pig farm affected by African swine fever [Poster presentation]. SVEPM 2018 – Classic problems, future focus, and engagement of stakeholders in veterinary epidemiology and economics, Tallinn, Estonia.
3. **Seržants**., M. (2018. May 16). African Swine Fever – The Experience of Latvia. Conference: The Threat of African Swine Fever in Europe: The Key Role of Hunters European Parliament, Brussels
4. **Seržants**., M., Aktualitātes savvaļas dzīvnieku infekcijas slimību uzraudzībā. (22. februāris 2019) Konference "Medības", Rīga, Latvijā.
5. Lamberga, K., Depner, K., Viltrop, A., Oļševskis, E., **Seržants, M**., & Bērziņš, A. (2020, January 29–30). Can we improve ASF control by learning from outbreaks? [Conference presentation]. Final International Conference of the COST Action ASF-STOP – Understanding and Combating African Swine Fever in Europe, Brescia, Italy.
6. **Seržants**., M., Āfrikas cūku mēris un meža cūku populācija Latvijā. (29. aprīlis 2022) Konference "Medības", Rīga, Latvijā.
7. **Seržants**., M., ĀCM 10. gadi Latvijā (19. aprīlis 2024) Konference "Medības", Rīga, Latvijā.
8. Ozoliņš, J., Bagrade, G., Blūms, K., Done, G., Oļševskis, E., Ornicāns, A., Pilāte, D., **Seržants, M**., Stepanova, A., & Šuba, J. (2025, March 27–29). Wanted dead or alive – Wild boar (*Sus scrofa*) control challenges concerning African swine fever outbreak in Latvia [Conference presentation]. 12th Baltic Theriological Conference "Baltic Mammals in the Turbulence of Anthropogenic Tensions", Latvia.
9. **Seržants, M**. (2026, March 28). Risks and preventive measures of *Tropilaelaps* spp. in Latvia [Conference presentation]. Spring Beekeeping Conference, Latvia.
10. **Seržants, M**., Lamberga, K., Ozoliņš, J., Kirjušina, M., & Oļševskis, E. (2026, April 9–10). The impact of African swine fever on the wild boar population in Latvia [Conference presentation]. 68th International Scientific Conference of Daugavpils University, Daugavpils, Latvia.

IEVADS

Pētījuma aktualitāte un novitāte

Latvijā Āfrikas cūku mēris (ĀCM) pirmo reizi tika apstiprināts 2014. gada 25. jūnijā meža cūku populācijā (**I**).

Slimības uzraudzības un apkarošanas pasākumi ir noteikti Eiropas Savienības normatīvajos aktos (Padomes Direktīva 2002/60/EK, 2002; Komisijas lēmums 2003/422/EK, 2003; Komisijas Īstenošanas lēmums 2014/709/ES, 2014; Komisijas Īstenošanas regula (ES) 2021/605, 2021; Komisijas Īstenošanas regula (ES) 2023/594, 2023)), kas sākotnēji bija balstīti uz Spānijas pieredzi (1960-1995) ĀCM 1 genotipa apkarošanā un laika gaitā tika pilnveidoti, ņemot vērā jauniegūto pieredzi un zinātnisko pētījumu rezultātus. Klimata, lauksaimniecības nozares un medību saimniecību izmaiņu ietekmē meža cūku populācija Eiropā būtiski palielinājās (**II**).

ĀCM apkarošanas stratēģijas sākotnējās darbības ir saistītas ar medību ierobežojumiem skartajā teritorijā, taču ieviešanas praktiskās pieredzes trūkuma dēļ sākotnējie mērķi netika sasniegti **(II)** un tā rezultātā slimība izplatījās no Baltkrievijas pierobežas valsts rietumu virzienā. Līdzīga slimības attīstība notika Lietuvā, Polijā un Igaunijā (**I, II, III**).

Tā kā meža cūku populācija ir ĀCM vīrusa (ĀCMV) rezervuārs, apkarošanas pasākumi galvenokārt saistīti ar populācijas kontroli. Salīdzinot ar likumdošanā precīzi definētiem slimības apkarošanas pasākumu algoritmiem mājas cūku novietnēs, savvaļas dzīvnieku pārvietošanās ierobežošana, skaita novērtēšana un samazināšana ir sarežģītu pasākumu kopums, kuru ieviešanā ir nepieciešama starpdisciplināra valsts, pašvaldību iestāžu un nevalstisko organizāciju ilgtermiņa sadarbība. (**II, III, IV**). 2018./2019. gada medību sezonā tika novērota būtiska epidemioloģiskās situācijas uzlabošanās, kas viesa cerību slimības likvidēšanā meža cūku populācijā (**III**), taču pēc ĀCMV reintrodukcijas no Krievijas Federācijas 2021.gadā tika novērota strauja ĀCM izplatīšanās Latgales un Vidzemes reģionos.

Mednieku pieņemtie ētikas apsvērumi un ilgtspējīgas medību saimniecības pamatprincipi ir balstīti uz medījamo dzīvnieku skaita saglabāšanu, t.sk., sivēnmāšu saudzēšanu, kas ir pretrunā ar ĀCM apkarošanas pamatprincipiem. Eiropas Komisijas 2023. gada 16. marta Īstenošanas regula (ES) 2023/594, ar ko nosaka īpašus slimības kontroles pasākumus attiecībā uz Āfrikas cūku mēri un atceļ Īstenošanas regulu (ES) 2021/605, nosaka dalībvalstīm prasību izstrādāt meža cūku populācijas un ĀCM uzraudzības un apkarošanas plānus. Šī dokumenta ieviešanas sekmes pilnā mērā ir atkarīgas no mednieku ieinteresētības, pasākumu akceptēšanas un ievērošanas ilgtermiņā.

Promocijas darba laikā iegūtie rezultāti un secinājumi tika izmantoti par pamatu Latvijas apstākļiem un medību saimniecību specifikai atbilstošas Āfrikas cūku mēra uzraudzības un apkarošanas stratēģijas izstrādē, kas apstiprināta ar Zemkopības Ministrijas rīkojumu Nr. 113 (5.09.2023.) "Par Āfrikas cūku mēra uzraudzības un apkarošanas stratēģiju 2023.–2028. gadam". Stratēģijas prioritātēs ir iekļauti šādi savstarpēji papildinoši pasākumi, kas, balstoties uz Latvijas un citu valstu pieredzi, var būtiski veicināt ĀCM apkarošanu meža cūku populācijā:

1. Izstrādāt precīzu un praktiski izmantojamu uzskaites sistēmu meža cūku skaita noteikšanai un to ieviest visā Latvijas teritorijā meža cūku skaita kontrolei.
2. Samazināt un uzturēt meža cūku populāciju līdz blīvumam 0,15 meža cūkas uz 1 km^2, visā Latvijas teritorijā.
3. Ievērot un kontrolēt biodrošības pasākumus medībās un medījumu pirmapstrādē.
4. Ievērot un kontrolēt biodrošības pasākumus mājas cūku novietnēs.
5. Veicināt medījumu gaļas nonākšanu pārtikas apritē.

Promocijas darba praktiska nozīme

Promocijas darba praktiskā nozīme ir saistīta ar ĀCM apkarošanas pasākumu pilnveidošanu, balstoties uz Latvijā iepriekš iegūto pieredzi. Pētījuma ietvaros uzkrātā un analizētā informācija par slimības izplatību, uzraudzības efektivitāti un īstenotajiem kontroles pasākumiem nodrošina zinātniski pamatotu platformu turpmākai ĀCM apkarošanas stratēģijas pilnveidošanai.

Darba rezultāti ir izmantojami, lai uzlabotu uzraudzības sistēmu, optimizētu meža cūku populācijas pārvaldības pieejas un stiprinātu sadarbību starp iesaistītajām pusēm, jo īpaši medību tiesību lietotājiem. Tāpat iegūtie rezultāti, secinājumi un sniegtās rekomendācijas var tikt izmantotas gan nacionālā, gan starptautiskā līmenī, pilnveidojot ĀCM kontroles un ierobežošanas pasākumus.

Darba hipotēze

ĀCM izplatība meža cūku populācijā Latvijā galvenokārt ir saistīta ar vīrusa saglabāšanos vides rezervuāros (inficētu meža cūku līķos) un nepietiekami mērķētu populācijas pārvaldību. Šos faktorus iespējams mazināt, integrēti kombinējot mērķtiecīgus populācijas kontroles pasākumus, pilnveidotu slimības uzraudzības stratēģiju un ciešāku ieinteresēto pušu sadarbību.

Darba mērķis

Novērtēt ĀCM ietekmi uz meža cūku populāciju Latvijā un izstrādāt zinātniski pamatotas ĀCM kontroles un apkarošanas pasākumu rekomendācijas meža cūku populācijā.

Uzdevumi

1. Analizēt ĀCM epidemioloģiskās situācijas dinamiku Latvijas meža cūku populācijā.
2. Novērtēt ĀCM uzraudzības sistēmas principus meža cūku populācijā.
3. Izvērtēt Latvijā īstenoto ĀCM kontroles pasākumu efektivitāti meža cūku populācijā.
4. Apkopot meža cūku bioloģiskos un ekoloģiskos faktorus, kas ietekmē ĀCM izplatību un vīrusa noturību populācijā.
5. Analizēt mednieku lomu un iesaisti ĀCM uzraudzībā un kontroles pasākumos.
6. Izstrādāt rekomendācijas ĀCM kontroles un apkarošanas pasākumu efektivitātes uzlabošanai meža cūku populācijā.

1. LITERATŪRAS APSKATS

1.1. Meža cūkas (Sus scrofa) bioloģija

Meža cūka (*Sus scrofa*) ir pārnadžu kārtas (Artiodactyla) cūku dzimtas (Suidae) suga (Prothero & Foss, 2007; Andersone-Lilley et al., 2010). Salīdzinājumā ar citām pārnadžu sugām meža cūkām raksturīgs īpaši augsts reproduktīvais potenciāls un izteikts ekoloģiskais plastiskums, kas ļauj tām veiksmīgi pielāgoties dažādiem trofiskajiem resursiem un vides apstākļiem (Keuling et al., 2013). Meža cūkas apdzīvo dažādu tipu mežus, lauksaimniecības zemes, kā arī arvien biežāk sastopamas urbanizētās teritorijās. Vasaras periodā tās galvenokārt uzturas lapkoku mežos ar blīvu jaunaudzi, savukārt ziemā biežāk sastopamas egļu, jauktos lapkoku–egļu vai egļu–priežu mežos (Tauriņš, 1982; Sāvičs, 2014; Jori et al., 2021).

Meža cūka ir visēdāja suga ar ļoti plašu barības spektru. Tās uzturā ietilpst augu sēklas, saknes, gumi, ogas, sēnes un ozolu zīles, kā arī dzīvnieku izcelsmes barība, tostarp krituši dzīvnieki (tai skaitā meža cūkas), kukaiņu kāpuri, sliekas, gliemji, abinieki, rāpuļi, sīkie zīdītāji, putnu olas un putnu vai zīdītāju mazuļi. Papildus dabiskajai barībai meža cūkas daudzviet tiek regulāri piebarotas. Pētījumi liecina, ka piebarošanas apjomi, kādi pašlaik tiek praktizēti daudzās Eiropas valstīs, ir pārmērīgi un būtiski ietekmē populācijas dinamiku (Guberti et al., 2022).

Parasti meža cūku mātītes sasniedz dzimumgatavību aptuveni 1,5 gadu vecumā, sasniedzot 27–33 kg dzīvsvaru, savukārt tēviņi – apmēram trīs gadu vecumā (Tauriņš, 1982; Cukor et al., 2020; Jori et al., 2021). Labvēlīgos vides apstākļos, īpaši regulāras piebarošanas ietekmē, dzimumgatavība var iestāties agrāk, un mātītes var sākt vairoties jau pirmajā dzīves gadā. Grūsnības ilgums ir vidēji 114–140 dienas, un vienā metienā parasti piedzimst 4–7 sivēni. Metiena lielums būtiski atkarīgs no mātītes vecuma un fiziskā stāvokļa – jaunām mātītēm tas parasti ir mazāks, savukārt nobriedušām mātītēm lielāks. Īpaši nelabvēlīgos apstākļos līdz nākamajam pavasarim izdzīvo tikai aptuveni 20% jauno dzīvnieku. Riests parasti sākas novembra otrajā pusē un ilgst apmēram vienu mēnesi, tomēr siltās ziemās un labos barošanas apstākļos meža cūku vairošanās var kļūt nesezonāla un daļai populācijas noritēt nepārtraukti (Tauriņš, 1982; Jori et al., 2021).

Regulāras piebarošanas rezultātā mātīšu auglība var ievērojami pieaugt, pat divkāršoties, un populācijas līmenī būtiski palielinās jaundzīvnieku skaits. Dabiskos apstākļos šāds populācijas pārpalikums labvēlīgas vides ietekmē būtu iespējams tikai reizi 3–4 gados, taču piebarotās populācijās meža cūkas faktiski katru gadu piedzīvo "labvēlīgus gadus" (Guberti et al., 2022).

Pēdējo desmitgažu laikā meža cūku populācija Eiropā, tostarp Latvijā, ir piedzīvojusi strauju pieaugumu. Demogrāfisko ekspansiju veicinājuši vairāki faktori, tostarp izmaiņas lauksaimniecības zemju izmantošanā, klimata un vides pārmaiņas, kā arī medību slodzes samazināšanās (Baumanis, 2013; Keuling et al., 2013; Guberti et al., 2022).

Neskatoties uz meža cūku plašo izplatību Eiropā un citviet pasaulē, tās ietekme uz ekosistēmām joprojām nav pietiekami izprasta. Lai gan suga ir viena no ekoloģiski ietekmīgākajām lielo zīdītāju sugām un tās klātbūtne saistīta ar augsnes uzirdināšanu, veģetācijas izmaiņām, ietekmi uz bezmugurkaulnieku un sīko mugurkaulnieku populāciju, meža cūku radītā ietekme bieži tiek vērtēta lokālā vai sektorālā griezumā (piemēram, zaudējumi lauksaimniecībai), bet nepietiekami tiek analizēta tās sistēmiskā loma biotopu struktūras un funkciju pārveidē (Massei & Genov, 2004; Augustsson et al., 2025; Massei, 2026).

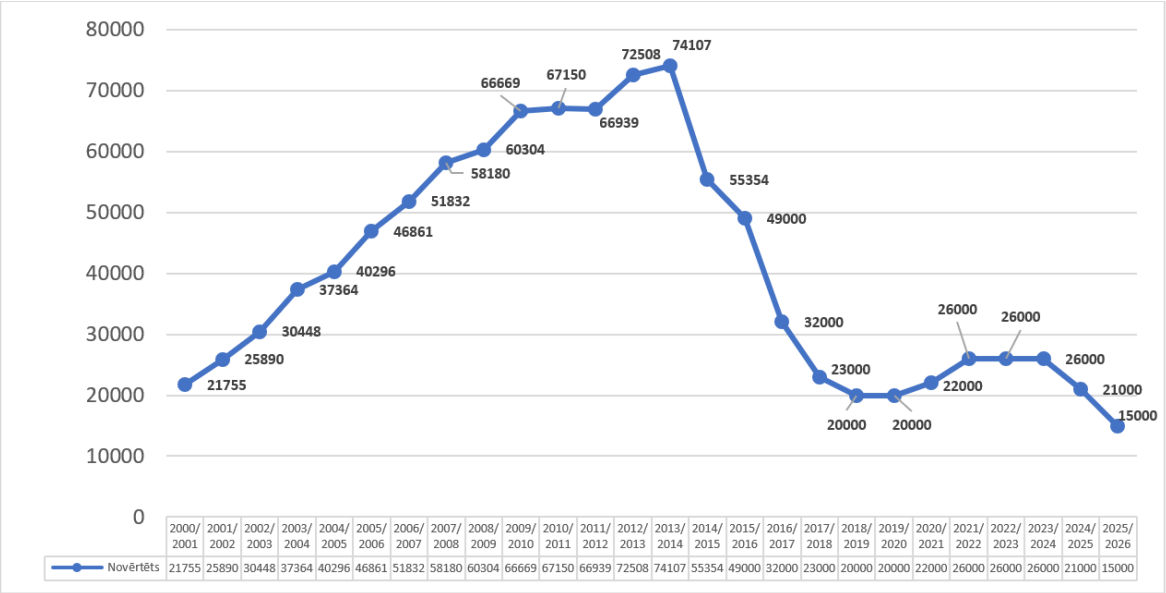
Saskaņā ar Latvijā spēkā esošajiem normatīvajiem aktiem meža cūka ir nelimitēts medījamais dzīvnieks, kuru atļauts medīt visu gadu individuālajās medībās, kā arī dzinējmedībās no 1. oktobra līdz 31. janvārim. Medības atļautas arī diennakts tumšajā laikā no paaugstinājuma, izmantojot mākslīgos gaismas avotus, nakts redzamības un termālos tēmēkļus, kā arī pusautomātiskos medību šaujamieročus ar patronu padošanas mehānisma ietilpību, kas pārsniedz trīs patronas, šos faktus fiksējot medību pārskatā. Meža cūku dzīvķeršana ar lamatām ir atļauta tikai ar Valsts meža dienesta (VMD) atļauju (Medību noteikumi, 2014).

Meža cūku populācijas lielumu Latvijā VMD novērtē katru gadu uz 1. aprīli noteiktās uzskaites vienībās – vienlaidus teritorijās ar dabā esošām robežām, kas ietver vienu vai vairākus medību iecirkņus un kuru platība meža cūkām nav mazāka par 1500 ha. Dzīvnieku skaits tiek noteikts neatkarīgi no medību iecirkņu administratīvajām robežām, un, ja nepieciešams, sadalīts pa iecirkņiem proporcionāli to platībai vai ņemot vērā dzīvnieku telpiskā izvietojuma īpatnības (Kārtība Nr. 18, 2018).

Tomēr populācijas uzskaites dati var būt maldinoši, jo tie atspoguļo vidējo, izlīdzināto meža cūku blīvumu plašās teritorijās. Izmantotās uzskaites un monitoringa metodes sniedz tikai vispārīgu priekšstatu par populācijas lielumu valsts vai reģionālā līmenī un ir īpaši neprecīzas pie zema dzīvnieku blīvuma (Gervasi et al., 2022; Guberti et al., 2022).

Pirms Āfrikas cūku mēra (ĀCM) konstatēšanas Latvijā 2014. gadā meža cūkas bija visbiežāk sastopamais un populārākais lielais medījamais dzīvnieks, veidojot gandrīz 70% no visiem gadā nomedītajiem pārnadžiem. Saskaņā ar VMD datiem 2013. gadā Latvijā bija 74107 meža cūkas. Pēc ĀCM apstiprināšanas populācija būtiski samazinājās – līdz aptuveni 20000 indivīdu 2018./2019. gada medību sezonā (samazinājums par 73%). 2021./2022. gada medību sezonā tika novērotas populācijas atjaunošanās pazīmes, un novērtētais meža cūku skaits

palielinājās par aptuveni 30%, sasniedzot apmēram 26 000 indivīdu (1. attēls). Taču jau sākot ar 2024./2025. medību sezonu populācijas samazināšanos izraisīja atkārtota ĀCM vīrusa izplatīšanās meža cūku populācijā. (Ozoliņš et al., 2025; PVD 2025; VMD 2026).

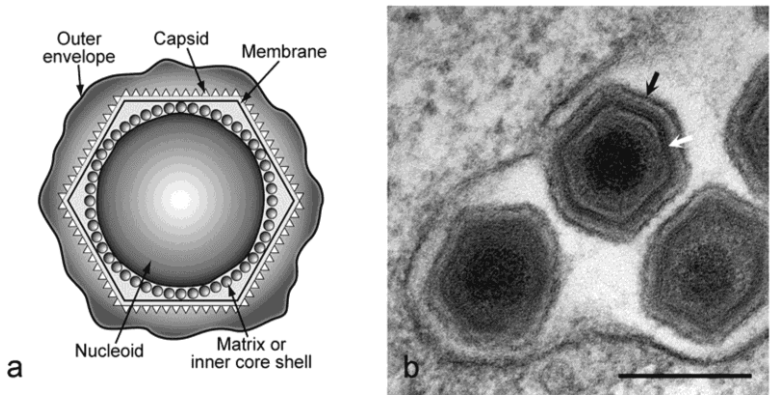


1. Attēls. Novērtētais Meža cūku (*Sus scrofa*) skaits Latvijā (VMD uzskaite https://www.vmd.gov.lv/lv/medijamo-dzivnieku-populacijas)

1.2 Āfrikas cūku mēra vīruss

ĀCMV ir liels (175–215 nm), apvalkots DNS vīruss un pašlaik vienīgais zināmais Asfarviridae dzimtas Asfivirus ģints pārstāvis. Vīrusam ir ikosahedriska forma (2. attēls) (Blome et al., 2012; Gallardo et al., 2015). Vīruss galvenokārt replicējas inficēto šūnu citoplazmā. ĀCMV genoms ir lineāra DNS molekula (~170–194 kb), kas kodē 150–200 proteīnus, tostarp ar virulenci un imūnās atbildes nomākšanu saistītus faktorus. Molekulārajā epidemioloģijā vīrusu iedala 24 genotipos (I–XXIV), balstoties uz p72 (B646L) gēna secību. ĀCMV inficē mājas cūkas un meža cūkas, galvenokārt skarot monocītus un makrofāgus (Bastos et al., 2003; Chapman et al., 2008; Sánchez-Vizcaíno et al., 2012; Costard et al., 2013; Dixon et al., 2013; Rodríguez & Salas, 2013; Gallardo et al., 2015; Qu et al., 2022).

ĀCMV ļoti izturīgs zemās temperatūrās (gadiem ilgi saldētā gaļā), ilgstoši saglabājas asinīs, izkārnījumos un audos, kā arī termiski neapstrādātos vai nepietiekami apstrādātos cūkgaļas produktos. Savukārt karstumā inaktivējas 70 minūšu laikā pie +56°C un 20 minūšu laikā pie +60°C. Augstā vīrusa noturība vidē būtiski apgrūtina slimības kontroli (Alonso et al., 2018; WOAH 2019).



2. attēls. ĀCMV viriona struktūra.

(a) Shematisks viriona uzbūves attēlojums, kurā parādīti galvenie strukturālie komponenti: centrālais nukleoīds ar vīrusa genomu, iekšējais kodols (core shell), iekšējā lipoproteīnu membrāna, ikosaedriskais kapsīds un ārējais apvalks. (b) Transmisijas elektronmikroskopijas (TEM) attēls ar ekstracelulāriem ĀCMV virioniem. Melnā bultiņa norāda uz ārējo apvalku, bet baltā bultiņa – uz kapsīdu. Skalas josla = 200 nm. Paraugi sagatavoti, izmantojot standarta ķīmiskās fiksācijas un kontrastēšanas metodi transmisijas elektronmikroskopijai (Alonso et al., 2018).

ĀCMV apdraud tikai Suidae dzimtas dzīvniekus. Eiropā vienīgās uzņēmīgās sugas ir mājas cūkas (*Sus scrofa domesticus*) un meža cūkas (*Sus scrofa*) (Iannucci., 2022). Tām ir līdzīgas klīniskās pazīmes un līdzīga mirstības proporcija. Pirmo reizi par ĀCM tika ziņots Kenijā 1921. gadā. Slimība ir endēmiska daudzās Āfrikas valstīs. Lai gan kopumā Āfrikā cirkulē 24 vīrusa genotipi, Eiropā līdz 2019. gadam bija sastopams I. un II. genotips (Penrith, 2009; Guberti et all., 2022).

ĀCMV 1. genotips bija pirmais no genotipiem, kas izplatījās ārpus Āfrikas un dominēja Eiropā 20. gadsimta otrajā pusē. Pirmais uzliesmojums Eiropā tika reģistrēts 1957. gadā Portugālē, kam sekoja vīrusa izplatība vairākās Rietumeiropas valstīs, tostarp Spānijā, Francijā, Beļģijā, Nīderlandē, Itālijā un Maltā (Penrith, 2009; Sánchez-Cordón et al., 2018; Cwynar et al., 2019). Bijušās Padomju Savienības teritorijā ĀCM pirmo reizi tika konstatēts 1977. gadā Ukrainā Odesas apgabalā, kur, visticamāk, vīrusu ar inficētiem cūkgaļas produktiem Odesas ostā ieveda jūrnieki. Uzliesmojumi skāra galvenokārt mājas cūkas, un izolāti piederēja ĀCMV 1. genotipam, kas bija ģenētiski radniecīgs tā laika Eiropā izplatītajiem celmiem. 70. gadu beigās ĀCMV 1. genotips tika konstatēts arī Brazīlijā, Kubā un Karību jūras salās, kur stingru veterināro un administratīvo pasākumu rezultātā vīrusa izplatība tika likvidēta dažu gadu laikā (Sánchez-Vizcaíno et al., 2012; Gogin et al., 2013; Korennoy et al., 2017).

Intensīvu kontroles pasākumu rezultātā ĀCMV 1. genotips līdz 1990. gadu vidum tika izskausts visā kontinentālajā Eiropā (Danzetta et al., 2020).

Izņēmums Eiropā bija Sardīnija, kur ĀCMV 1. genotips kopš 1978 gada vairāk kā četrdesmit gadus saglabājās endēmisks un pilnībā to izdevās likvidēt tikai 2019 gadā (Franzoni et al., 2020; Cappai et al., 2022; Qu et al., 2022; Pavone et all., 2023; Dei Giudici et al., 2024).

ĀCMV 2. genotips Ārpus Āfrikas pirmo reizi tika konstatēts Gruzijā 2007. gadā. Slimības strauja izplatība mājas un meža cūku populācijā notika pēc ĀCMV nonākšanas Krievijas Federācijā. Čečenijā ĀCMV tika konstatēts meža cūku populācijā 2007. gada novembrī. 2008. gadā Ziemeļosetijā mājas cūku novietnēs un 2009. gadā ĀCM tika apstiprināts Ļeningradas apgabalā. Laika posmā no 2007. līdz 2014. gadam cilvēku darbības rezultātā ĀCMV izplatījās uz centrālajiem un ziemeļrietumu Krievijas reģioniem, kur meža cūku populācija kļuva par vīrusa rezervuāru un endemizācijas faktoru, padarot Krievijas teritoriju par nozīmīgu sekundāru infekcijas avotu Austrumeiropā (Penrith, 2009; Oganesyan et al., 2012; Gogin et al., 2013; Vergne et al., 2017; Cwynar et al., 2019).

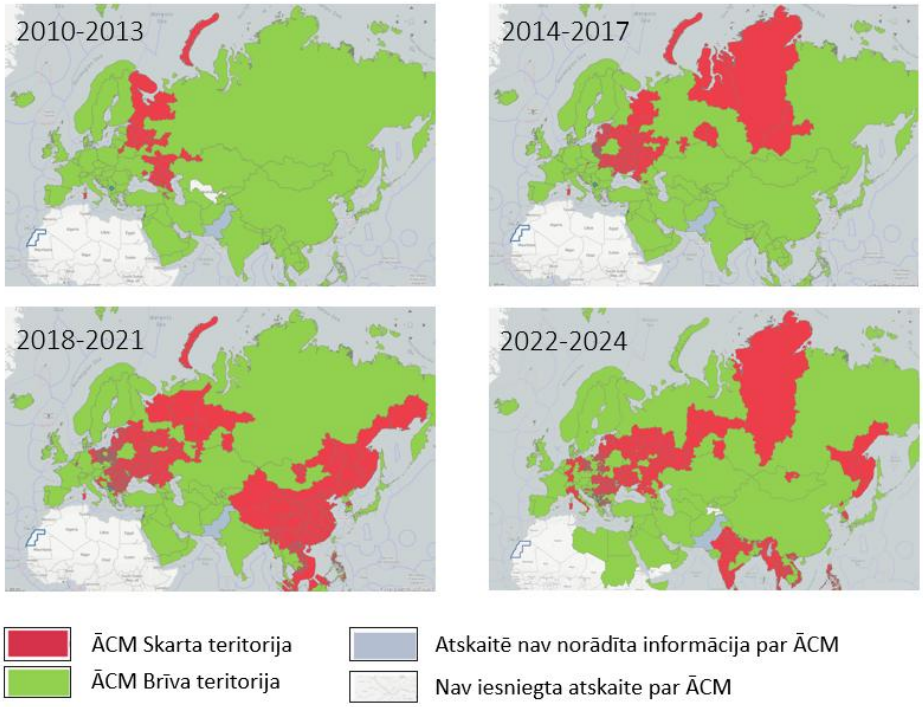
Ukrainā (kopš 2012. gada) un Baltkrievijā (kopš 2013. gada) ĀCMV 2. genotipa ievazāšana tika saistīta ar cilvēka izraisītu pārrobežu pārnesi un meža cūku migrāciju no Krievijas (Špakauskas et al., 2016; Cwynar et al., 2019; Shakun., 2021). Eiropas Savienību epidēmija pirmo reizi sasniedza 2014. gadā, kad ĀCM tika konstatēts Lietuvā 2014. gada janvārī (Pautienius et al., 2018) un neilgi pēc tam arī februārī Polijā (Smietanka et al., 2016). Latvijā ĀCM pirmo reizi tika apstiprināts meža cūku populācijā 2014. gadā jūnijā Baltkrievijas pierobežā (I.).

Šobrīd, neskaitot Āfriku, ĀCMV 2. genotips ir konstatēts vairāk ka 30 valstīs Eiropas un Āzijas reģionā (Sauter-Louis et al., 2021, WOAH) (3. attēls).

Konstatēts, ka infekcija spēj saglabāties lokāli meža cūku populācijā neatkarīgi no slimības uzliesmojumiem mājas cūku novietnēs. No uzraudzības datiem var novērot, ka epidemioloģiskais vilnis meža cūku populācijā virzās lēni (~1-5 km/mēnesī), nogalinot lielāko daļu meža cūku slimības skartajā teritorijā (Chenais et al., 2018).

ĀCMV meža cūku populācijā izveido meža cūku ciklu (*wild boar–habitat cycle)*, tādējādi meža cūkai kļūstot par vīrusa rezervuāru. Meža cūku ciklā inficēšanās notiek tiešā kontakta ceļā, no inficēta uz uzņēmīgu dzīvnieku, kā arī netiešā kontakta ceļā, kad uzņēmīgi dzīvnieki inficējas no inficētu meža cūku līķiem vai kontaminētas vides (Costard et al., 2013; Arias et al., 2017; Cukor et al., 2020; Viltrop et al., 2021; Guberti et al., 2022).

Zemākā temperatūrā meža cūku līķu sadalīšanās un vīrusa inaktivēšanās notiek ievērojami ilgākā laika periodā, attiecīgi paildzinās periods, kurā uzņēmīgi dzīvnieki var nonākt kontaktā ar kontaminētu materiālu, inficēties un sekmēt infekcijas tālāku izplatību populācijā (Chenais et al., 2018; Probst et al., 2020).



3. attēls. ĀCM skartās valstis Eiropas un Āzijas reģionā, laika posmā no 2010 – 2024. gadam, saskaņā ar Pasaules dzīvnieku veselības organizācijas (WOAH) WAHIS datu bāzi https://wahis.woah.org/#/dashboards/country-or-disease-dashboard

Tikai neliela daļa no inficētajiem dzīvniekiem atveseļojas un izdzīvo. Nomedīto meža cūku seroprevalence svārstās no 0,5 līdz 2% (Guberti et al., 2022). Taču nav iegūti pierādījumi, ka izdzīvojušām seropozitivām un vīrus negatīvām meža cūkām ir būtiska loma ĀCM epidemioloģijā (Stahl et al., 2019; Oļševskis et al., 2023).

ĀCM vakcīnas izstrāde ir sarežģīta, jo ĀCM vīruss ir liels un genomiski komplekss DNS vīruss ar vairāk nekā 150 gēniem un izteiktiem imūnmodulācijas mehānismiem. Aizsargājošās imunitātes mehānismi pret ĀCMV joprojām nav pilnībā izprasti, un līdz šim nav identificēti skaidri imunitātes korelāti, kas nodrošinātu pilnīgu aizsardzību pret infekciju. Pašlaik visperspektīvākie vakcīnu kandidāti ir ģenētiski modificētas dzīvas novājinātas vakcīnas, kas spēj radīt efektīvu imūnreakciju, tomēr to praktisko izmantošanu ierobežo drošības apsvērumi un nepieciešamība nodrošināt DIVA (*Differentiating Infected from Vaccinated Animals*) pieeju, kas ļautu atšķirt vakcinētus un inficētus dzīvniekus. Lai arī aktīvs darbs pie vakcīnas izstrādes norit jau vairāk kā četras desmitgades un ir radīti vairāki vakcīnu kandidāti, droša un efektīva vakcīna pret ĀCM joprojām nav pieejama (Gallardo et al., 2015; Zakaryan et al., 2016; Arias et al., 2017; Galindo & Alonso, 2017; Rock et al., 2017; Cwynar et al., 2019; Sánchez et al., 2019; Borca et al., 2021; Li et al., 2022).

1.3. ĀCM apkarošanas pasākumi meža cūku populācijā

Līdz šim sekmīga slimības apkarošanas stratēģija ir īstenota tikai Čehijā, Beļģijā un Zviedrijā. Visās trīs valstīs īstenotie apkarošanas pasākumi, bija līdzīgi. Atšķirībā no citām valstīm Čehijā, Beļģijā un Zviedrijā notika tā saucamā "pilienveida" inficēšanās (uzliesmojumi telpiski atdalītos punktos, kas nav tieši saistīti ar iepriekš inficētām teritorijām un liecina par cilvēka starpniecību vīrusa izplatībā, nevis dabisku izplatīšanos meža cūku migrācijas ceļā). Kā arī teritorija, kurā tika konstatētas inficētās meža cūkas, bija salīdzinoši neliela (Šatrán 2019; Jori et al., 2021; Licoppe et al., 2023; World Organisation for Animal Health, 2024).

Apkarošanas pasākumi iekļāva sekojošas aktivitātes:

Ierobežojumu teritoriju definēšana. Teritorijas, kurās tika konstatētas ĀCM pozitīvas meža cūkas (inficētā zonā), sākotnēji tika noteikts pilnīgs jebkāda veida aktivitāšu (tūrisma, mežsaimniecības, lauksaimniecības, kā arī medību un dzīvnieku piebarošanas) aizliegums. Apkārt inficētajai teritorijai, tika noteikta buferzona, saukta arī par "balto zonu". Īstenotie pasākumi, katrā zonā un tika pielāgoti vietējām epidemioloģiskajām īpatnībām un epidemioloģiskai fāzei.

Meža cūku līķu meklēšana. Organizēta sistemātiska un mērķtiecīga meža cūku līķu meklēšana (pasīvā uzraudzība) un iznīcināšana. Meklēšanā tika iesaistīti vairāki simti cilvēku no reģiona mežsaimniecībām, militāristi, mednieki un citi valsts un nevalstisko organizāciju pārstāvji.

Nožogojums. Lai novērstu meža cūku kustību un palēninātu vīrusa izplatīšanos, tika izbūvēti 1,2 metru augsti stiepļu žogi. Žogi tika instalēti gar ceļiem, kā arī tika izmantoti citi dabīgi šķēršļi, lai palielinātu ainavas fragmentāciju.

Meža cūku depopulācija. Sākotnēji depopulācija tika uzsākta "baltajā zonā", lai novērstu vīrusa izplatīšanos ārpus inficētās teritorijas. Depopulāciju "baltajā zonā" ar valsts un pašvaldību institūciju atbalstu īstenoja mednieki. Papildus mednieku organizētajām medībām, "baltajā zonā" tika izmantotas tādas alternatīvas populāciju samazinošas metodes, kā dzīvķeršana un nakts medības (European Commission, 2023; Licoppe et al., 2023).

Līdzšinējā EK ĀCM apkarošanas stratēģija neparedz efektīvus pasākumus ĀCM endēmiskām teritorijām, kādām var pieskaitīt arī Latviju (Sauter-Louis et al., 2021; European Commission, 2023).

ĀCM meža cūku skartajās teritorijās pieaug mājas cūku inficēšanās riski. Inficēšanās iemesli galvenokārt ir kontaminēta barība, pakaiši, transporta līdzekļi un citi materiāli, kas nonāk cūku novietnē vai kontaktā ar dzīvniekiem (Guinat et al., 2016; I.; Zani et al., 2019; EFSA, 2020; Nurmoja et al., 2020).

Vīruss rada lielu sociālekonomisku ietekmi skartajos reģionos (Stahl et al., 2019; Niemi, 2020; European Parliament, 2023; Pepliński, 2025). Latvijā laika posmā no 2014 gada jūnija līdz 2025. gada decembrim ĀCM ir apstiprināts 102 mājas cūku novietnēs ar kopējo cūku skaitu 81 590. ĀCM ir apstiprināts 11 211 meža cūkām (PVD, 2025).

ĀCM apkarošana ir balstīta uz meža cūku populācijas (uzņēmīgo dzīvnieku) būtisku samazināšanu. Tomēr tradicionālo (rekreācijas) medību slodze nav pietiekoša, lai samazinātu un uzturētu populāciju nepieciešamajā līmenī, tāpēc ir nepieciešams izmantot koordinētas un mērķētas populācijas kontroles stratēģijas (Massei et al., 2015; Bartoš et al., 2021; Ozoliņš et al., 2025; Gortázar et al., 2026). Kā piemēram, kombinēt tradicionālās medības ar mērķtiecīgu reproduktīvo dzīvnieku medīšanu, dzīvķeramajiem sprostiem (lamatām), profesionālu mednieku iesaiste un koordinētas populācijas samazināšanas kampaņas (Massei et al., 2015; Pepin et al., 2017; Gortázar et al., 2026). Ar dzīvķeramo sprostu palīdzību var vienlaikus noķert vairākus īpatņus relatīvi īsā laikā. Metode ar labiem panākumiem izmantota Beļģijā (Massei et al., 2011; Jori et al., 2021).

Lai izstrādātu reālistiskus ĀCM apkarošanas pasākumus attiecībā uz meža cūku populāciju slimības skartajās teritorijās, nepieciešams ievākt un analizēt datus ar visaugstāko telpisko izšķirtspēju, vēlams individuālo medību platību līmenī (Iacolina et al., 2021; Gervasi et al., 2022; Guberti et al., 2022; Ozoliņš et al., 2025).

Latvijā un Eiropā mednieku skaitam ir tendence samazināties. 2024. gadā VMD medniekiem Latvijā izsniedza 19046 sezonas kartes, kas ir par 9,6% mazāk nekā 2014. gadā (Massei et al., 2015; VMD 2025). Taču, ņemot vērā mednieku skaitu, klātesamību medību platībās un apvidus pārzināšanu, mednieki bija un būs nozīmīgākie partneri ĀCM apkarošanā (Guberti et al., 2022; Stončiūtė et al., 2022; Gröndal et al., 2025).

Lai arī mednieki ir ieinteresēti stabilā un veselīgā meža cūku populācijā, līdzšinējā Latvijas un citu valstu pieredze rāda, ka ne vienmēr mednieki pilnībā izprot un pieņem apkarošanas pasākumus. Slimības apkarošanas pasākumi galvenokārt ir saistīti ar populācijas drastisku samazināšanu vai populācijas uzturēšanu ļoti zemā līmenī. Lai veicinātu izpratni un sasniegtu nepieciešamos uzdevumus, nepieciešams medniekus vairāk izglītot un iesaistīt aktivitātēs, kas saistīti ar ĀCM apkarošanas pasākumiem (Urner et all., 2021; Gröndal et al., 2025).

2. MATERIĀLI UN METODES

2.1. Pētāmie dati (I, II, III)

ĀCMV Latvijā 2014. gadā tika laboratoriski apstiprināts 217 meža cūkām 32 mājas cūku novietnēs.

Lai novērtētu Latvijā ieviestos ĀCM kontroles pasākumus meža cūku populācijā tika analizēti dati par 41 mēnešu periodu no 25.06.2014. (pirmais ĀCM apstiprinātais gadījums Latvijā) līdz 31.10.2017.

Meža cūku populācijas (populācijas blīvuma) dati par 2014/15, 2015/16, 2016/17 medību sezonām (no gada aprīļa līdz nākamā gada martam) medību uzskaites vienību griezumā tika iegūti no VMD. Meža cūku skaita novērtēšanu un aprēķināšanu veic VMD amatpersonas par katru medību uzskaites vienību, balstoties uz iepriekšējā sezonā nomedīto dzīvnieku skaitu (dzimumu un vecumu proporciju), novērojumiem (dzīvnieku pēdas u.c.) kā arī informāciju par postījumiem lauksaimniecībai. Populācijas skaita novērtēšana tiek veikta katru gadu uz 1. aprīli.

Savukārt ĀCM epidemioloģiskās situācijas novērtēšanai tika izmantoti ĀCM laboratoriskās uzraudzības dati par piecām medību sezonām (2014/2015 – 2018/2019).
Lai aprēķinātu meža cūku blīvumu uz km², balstoties uz novērtēto dzīvnieku skaitu medību uzskaites vienībā, tika izmantota programmatūra ArcGIS ArcMap 10.3.1 (ESRI, Redlands, CA, USA (http://www.esri.com/).

Katrai laboratoriski izmeklētajai meža cūkai bija viena individuāla datu kopa, ar informāciju par datumu un vietu, kur dzīvnieks nomedīts vai atrasts beigts, dzīvnieka vecumu (< 1 gads, 1 - 2 gadi, > 2 gadi) un parauga laboratorisko izmeklējumu rezultātu (vīrusa genoma noteikšana ar PCR metodi un seroloģija ar ELISA metodi, kuri apstiprināti ar IPT metodi). Dati ar neskaidru rezultātu netika iekļauti pētījumā.

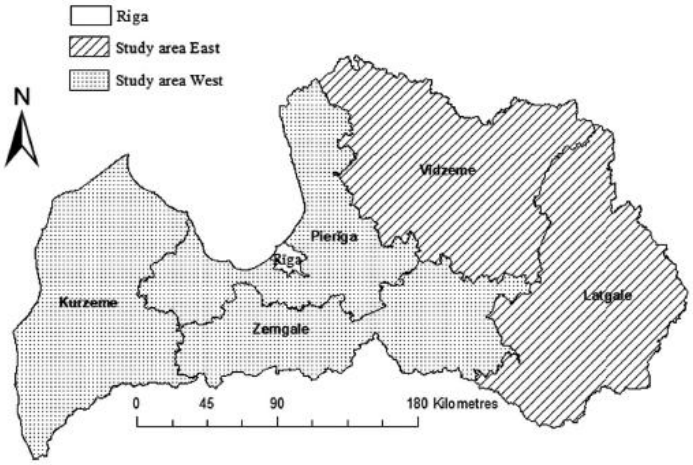
2.2. Pētījuma teritorija (I, II, III, IV)

2014. gada ĀCM izplatības analizēšanai tika izdalītas četras teritorijas Ziemeļlatgale, Dienvidlatgale, Madona un Vidzeme ar kopējo platību 12 909 km2.

Pētījuma teritoriju veidoja trīs dažādi Latvijas reģioni, t.i., Latgales reģions, kas robežojas ar Baltkrieviju, Vidzemes reģions, kas robežojas ar Igauniju, un Madonas novads (4. attēls). Kopumā pētījuma teritorija ietvēra 20 novadus ar kopējo platību aptuveni 15 146 km². No analīzes tika izslēgtas Daugavpils un Valmieras pilsētas.

4. attēls. Trīs pētījuma reģioni: Latgales reģions dienvidos, Vidzemes reģions dienvidos, Vidzemes reģions dienvidos un Madonas novads (II.).

Sakarā ar ĀCM lēno izplatību no Latvijas Austrumiem uz Rietumiem ĀCM epidemioloģijas datu analīzei valsts tika sadalīta Austrumu (Latgale un Vidzeme) un Rietumu (Pierīga, Zemgale un Kurzeme) daļā. Rīgas reģions tika izslēgts no analīzēm (5. attēls).



5. attēls. Seši statistikas reģioni Latvijā, kas sadalīti Austrumu un Rietumu daļā. Rīga analīzē netika iekļauta (III.).

Līdzdalības epidemioloģijas pētījumā tika iesaistīti dalībnieki (mednieki) no 5 Latvijas statistiskajiem reģioniem (Kurzemes, Latgales, Pierīgas, Vidzemes un Zemgales).

2.3. Laboratoriskā diagnostika (I, II, III)

Paraugu laboratorisko izmeklēšanu uz ĀCM vīrusa genoma klātbūtni un ĀCM specifiskajām antivielām veica ĀCM nacionālā references laboratorija – Pārtikas drošības,

dzīvnieku veselības un vides zinātniskā institūta "BIOR" (BIOR) Dzīvnieku slimību diagnostikas laboratorija. Asins paraugus no nomedītajām meža cūkām izmeklēšanai uz antivielu un ĀCM genoma klātbūtni noņēma mednieki. Savukārt paraugus no atrastajām beigtajām meža cūkām orgānu (nieru, liesas, limfmezglu) vai kaulu smadzeņu paraugus noņēma PVD inspektori un tos izmeklēja uz ĀCM genoma klātbūtni.

Laboratorijas procedūras ĀCMV genoma noteikšanai ar PCR vai antivielu noteikšanai ar ELISA palīdzību ir aprakstītas iepriekš (Schulz et al., 2019b).

2.3.1 Vīrusa genoma noteikšana

2014. un 2015. gadā ĀCM genoma noteikšana tika veikta ar reālā laika PĶR, bet no 2016. gada tika izmantots Eiropas Savienības ĀCM references laboratorijas izveidotais UPL protokols.

Vīrusa DNS tika ekstrahēta, izmantojot automatizēto nukleīnskābju izolēšanas sistēmu *NucliSENS® easyMAG®* (bioMérieux, Francija) saskaņā ar ražotāja norādījumiem. Ekstrakcijas efektivitātes un amplifikācijas kontrolei izmantoja heteroloģo iekšējās kontroles DNS (intype IC-DNA; QIAGEN, Vācija), ievērojot Hoffmann et al. (2006) aprakstīto principu (Lamberga et al., 2022). Polimerāzes ķēdes reakcija (PĶR) ĀCM vīrusa genoma noteikšanai tika veikta saskaņā ar Eiropas Savienības references laboratorijas ĀCM diagnostikas protokolu (Fernández-Pinero et al., 2013).

Rezultāti tika reģistrēti kā kvantifikācijas cikla (Ct) vērtības un interpretēti kā pozitīvi vai negatīvi atbilstoši iegūtajām Ct vērtībām.

2.3.2. Seroloģiskie izmeklējumi (ELISA un IPT)

Seroloģiskie izmeklējumi tika veikti, lai noteiktu ĀCM vīrusam specifiskas antivielas. Asins seruma paraugu izmeklēšanai saskaņā ar ražotāja norādījumiem tika izmantots komerciāli pieejamais bloķējošās ELISA tests Ingezim PPA Compac (11.PPA.K.3, Ingenasa, Madride, Spānija).

Papildus ELISA izmeklējumam seruma vai orgānu šķidruma paraugi tika izmeklēti, izmantojot netiešo imūnperoksidāzes testu (IPT) saskaņā ar Eiropas Savienības ĀCM references laboratorijas diagnostikas protokolu (European Union Reference Laboratory for ASF, 2018). IPT tika izmantots zemu antivielu titru noteikšanai, kurus nebija iespējams identificēt ar ELISA.

2.4. Līdzdalības epidemioloģijas pētījums (IV)

Līdzdalības epidemioloģija ir veterinārās epidemioloģijas metode, kas papildina tradicionālās epidemioloģiskās pieejas, integrējot sociālo un uzvedības zinātņu metodes. Līdzdalības epidemioloģijā fokusgrupas tiek izmantotas kā kvalitatīva datu vākšanas metode,

kas balstās uz mērķtiecīgi atlasītu dalībnieku diskusijām, lai identificētu vietējās zināšanas, uzvedības modeļus un uztveri par dzīvnieku slimībām un to kontroli. Šī pieeja ļauj integrēt ieinteresēto pušu praktisko pieredzi epidemioloģiskajā analīzē un uzlabot slimību uzraudzības un kontroles stratēģiju efektivitāti (Chambers, 1994; FAO, 2011).

Līdzdalības epidemioloģijas pētījumam, lai aptvertu visu Latvijas teritoriju, tika iesaistīti dalībnieki (mednieki) no pieciem Latvijas statistiskajiem reģioniem (Kurzemes, Latgales, Pierīgas, Vidzemes un Zemgales). Katrā reģionā tika organizētas divas fokusgrupu diskusijas. Pētījums tika īstenots sadarbībā ar Latvijas mednieku organizācijām ("Latvijas Mednieku asociācija" un "Latvijas Mednieku savienība") laika posmā no 2019. gada aprīļa līdz jūlijam. Katrā fokusgrupas diskusijā piedalījās trīs līdz seši mednieki, kuri tika mērķtiecīgi atlasīti, lai apkopotu dažādus mednieku viedokļus un uzskatus. Diskusijas tika strukturēta divās daļās. Pirmajā tika diskutēts par ĀCM ierobežošanas pasākumu pieņemšanu, bet otrajā daļā tika identificēti ierobežojošie vai motivējošie faktori, kas varētu ietekmēt mednieku atbalstu ĀCM pasīvajai uzraudzībai.

Pētījumā izmantotās līdzdalības metodes tika pielāgotas no Calba et al. (2015) un Schulz et al. (2016). Latvijā izstrādātā un pielietotā metodoloģija tika izmantota arī Igaunijā (Urner et al. 2020). Līdzdalības metožu rezultāti tika analizēti puskvantitatīvā veidā un ierakstīto diskusiju kvalitatīvie rezultāti tika iekļauti aprakstošā veidā.

2.5. Apkarošanas pasākumu novērtēšana (II, IV)

Lai analizētu ĀCM kontroles pasākumu ietekmi uz meža cūku populāciju vai novērtētu periodisko ĀCMV genoma izplatību, katram periodam tika noteikts piemērots kontroles periods, kura laikā tika īstenots konkrētais pasākums. Nosakot kontroles periodu, tika izvēlēta tāda pati sezona sezonu un mēnešu skaits kā periodā, kurā tika piemērots attiecīgais pasākums. Vislabāk būtu, ja kontroles periodā netiktu īstenots neviens cits pasākums, kas varētu ietekmēt saistītos parametrus (piemēram, nomedīto meža cūku skaita palielināšanos/atklāto beigto dzīvnieku skaita palielināšanos). Attiecīgi dažiem pasākumiem kontroles periodi bija jāizvēlas pirms un citiem - pēc periodiem, kad pasākumi tika piemēroti.

Pētījumā tika analizēti sekojoši ĀCM kontroles pasākumi, novērtējot to ietekmi uz atrasto beigto un nomedīto meža cūku paraugu proporciju vai ĀCMV genoma prevalenci:

M1 Atlīdzība par ziņošanu par atrastajiem meža cūku līķiem;

M2 Atlīdzība medniekiem par nomedītām meža cūkām;

M3 Dzinējmedību ierobežojumi;

M4 Atlīdzība par sivēnmāšu medīšanu;

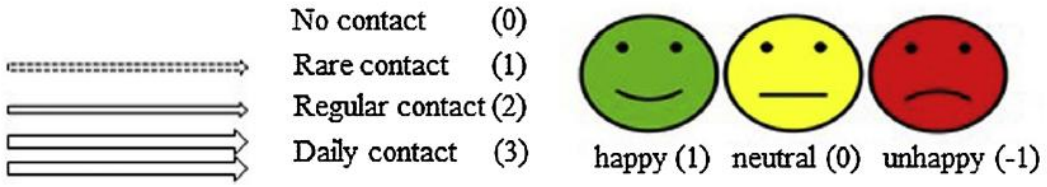
M5 Atļauja meža cūku medībās izmantot klusinātājus un nakts redzamības ierīces.

Lai novērtētu mednieku apmierinātību ar ĀCM apkarošanas pasākumiem un iesaistītajām pusēm (personām un institūcijām), tika izmantota sadarbības diagramma. Mednieki uzskaitīja ĀCM apkarošanas pasākumos iesaistītās puses un kontaktēšanās regularitāti, sadarbības ietvaros, apzīmēja ar bultām (sākot no "Nav kontaktu/sadarbības" līdz "regulāra/ikdienas sadarbība"). Savukārt katrs individuāli novērtēja sadarbības kvalitāti ar katru iesaistīto pusi ar emociju zīmi (Apmierināts, Neitrāls vai Neapmierināts) (6. attēls.).
Lai noteiktu mednieku atbalstu ĀCM apkarošanas pasākumu efektivitātei, tika izmantota 100 stikla lodītes, kuras tika sadalītas proporcionāli katra pasākuma efektivitātei.

Lai novērtētu uzticēšanos, mednieki izmantoja 100 stikla lodītes, kuras proporcionāli to uzticēšanas līmenim sadalīja pie katras no ĀCM apkarošanas pāsākumos uzskaitītās iesaistītās puses.

Dalībniekiem izvērtēšanai tika prezentēti sekojoši apakarošanas pasākumi:
- Žogu izmantošana;
- Medību aizliegums;
- Profesionālu mednieku iesaistīšana medību intensificēšanai (t.sk. policija un armija);
- Selektīvas sivēnmāšu medības;
- Medību finansiāla stimulēšana;
- Intensīva beigto meža cūku meklēšana un iznīcināšana.

Medniekiem bija iespēja pievienot papildus savus kontroles pasākumus. mednieki ar emociju zīmju palīdzību izteica savu personīgo viedokli par katru apkarošanas pasākumu.



6. attēls. Bultas un smaidiņi, kas tika izmantotas kontaktu biežuma darbības kvalitātes novērtēšanai (IV.).

2.6. Pasīvās uzraudzības novērtēšana (IV)

Ietekmes diagramma tika izmantota, lai novērtētu mednieku sagaidāmās negatīvās un pozitīvās ieviesto pasākumu sekas, ja tiek atrasta beigta meža cūka un tiek ziņots par to. Dalībnieki uzskaitīja visas paredzamās sekas (gan pozitīvās, gan negatīvās) un proporcionāli gaidāmajai ietekmei novērtēja sekas, sadalot 100 stikla lodītes.

Lai novērtētu mednieku motivāciju aktīvāk iesaistīties beigto meža cūku meklēšanā un ziņošanā (ĀCM pasīvā uzraudzība) tika piedāvāti sekojoši pasākumi:

- Kompensācijas palielināšana;
- Vīrusa aprites meža cūku populācijā samazināšana (atrodot, ņemot paraugus un iznīcinot beigtās meža cūkas);
- Tikai ziņošana par beigtām meža cūkām bez turpmāka darba medniekam
- Atgriezeniskā saite par atrastās beigtās meža cūkas laboratorisko izmeklējumu rezultātiem.

Lai novērtētu atbalstu katram pasākumam un tā pieņemšanu un motivāciju tika izmantota stikla lodītes, kuras tika sagrupētas proporcionāli katras aktivitātes pieņemšanai.

2.7. Statistikas analīze (II, III, IV)

Statistiskās analīzes tika veiktas, izmantojot programmatūras pakotni R (http://www.r-project.org., R Core Team, 2015). Ticamības intervāli tika aprēķināti saskaņā ar Clopper un Pearson. P-vērtība 9o ≤0,05 tika uzskatīta par statistiski nozīmīgu.

Populācijas datu un saistības starp potenciālajiem riska faktoriem lielākai iespējai atklāt ĀCM pozitīvos paraugus un ĀCM laboratorijas testa rezultātu statistiskā analīze tika veikta saskaņā ar Nurmoja, et al. (2017) aprakstīto.

Iespējamās sakarības starp vecumu, testa rezultātu, kā arī parauga iegūšanas veidu (nomedīta vai atrasta beigta) un testa rezultātu tika pārbaudītas izmantojot Fišera testu. Tika aprēķināta ĀCM genoma pozitīvo meža cūku attiecība (vīrusa izplatība jeb prevalence) un ĀCM specifisko antivielu pozitīvo mežacūku attiecība pret izmeklētajām (seroprevalence) ar attiecīgiem 95% ticamības intervāliem un analizēta šo rādītāju dinamika laikā.

Potenciālās populācijas blīvuma atšķirības dažādās medību sezonās tika analizētas, izmantojot neparametrisko *Kruskal-Wallis* testu. Ja tika konstatēta statistiski nozīmīga atšķirība, tika veikti pāru *Mann-Whitney U* testi. Lai kontrolētu I. tipa kļūdu vairākkārtējai testēšanai, šajos salīdzinājumos tika izmantota *Bonferroni* korekcija.

Ticamības intervāli katrā medību sezonā un katrā pētījuma apgabalā, tika aprēķināti saskaņā ar Clopper & Pearson (1935).

Tika aprēķināti visu iesaistīto pušu visu ĀCM apkarošanā iesaistīto pušu vērtējumi katras individuālās grupas ietvaros un visu grupu vidējie rezultāti.

Proporcionālā katra rādītāja novērtēšana tika analizēta un salīdzināta.

Piemēram, lai novērtētu uzticēšanos uzskaitītajiem apkarošanas pasākumiem tika veikts sekojošs aprēķins:

Uzticēšanās vidējais rādītājs *TCMi,* tika aprēķināts Apkarošanas pasākums *CMi* {1,….,28}, kurus uzskaitīja dalībnieki.

Pirmajā posmā tika aprēķināta kontroles pasākumiem *Pj* piešķirtā stikla lodīšu proporcija, stikla lodīšu skaits *GBij*, kas piešķirtas kontroles pasākumam *CMj* no grupas *Gj* ar j ∈ {1,…,10} attiecībā pret *ZjCM*, kontroles pasākumu skaits *CM*, kas uzskaitīti grupā *Gj*.

$$P_j = \frac{Z_j^{CM}}{\sum_{j=1}^{10} Z_j^{CM}}$$

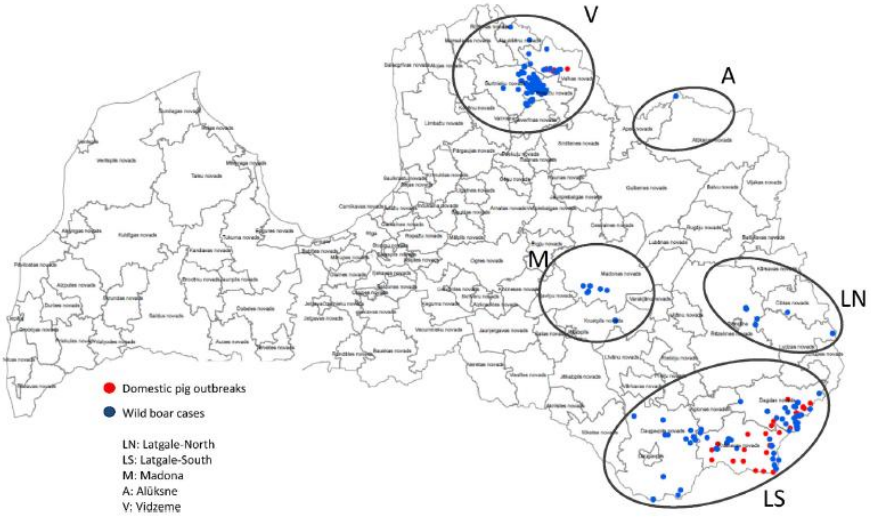
Vidējā uzticēšanās TCMi visiem kontroles pasākumiem tika aprēķināta ar NCMi, grupu G skaits pieminētie kontroles pasākumi CMj.

$$T_{CM_i} = \frac{1}{N_{CM_i}} \cdot \sum_{j=1}^{10} P_j \cdot GB_{ij}$$

3. REZULTĀTI

3.1. ĀCM epidemioloģiskā izplatība meža cūku un mājas cūku populācijā Latvijā (I)

Pirmās pozitīvās meža cūkas (n=7) tika konstatētas 2014.gada 25.jūnijā Dagdas novadā (Latgales - dienvidu reģions), kas atrodas uz robežas ar Baltkrieviju (7. attēls). Tiek uzskatīts, ka vīruss Latvijā nonāca ar inficētām meža cūkām 2014. gada jūnijā.



7. attēls. ĀCM saslimšanas gadījumu lokalizācija mājas un meža cūku populācijā Latvijā 2014. gadā (I.).

Latgales dienvidu reģionā līdz 2014. gadā tika konstatēti 77 meža cūku saslimšanas gadījumi. Latgales - ziemeļu daļā pozitīvi dzīvnieki (n = 9) tika konstatēti tikai no augusta līdz oktobrim. Tiešu saikni starp abiem atšķirīgajiem perēkļiem (Latgale-Dienvidi un Latgale-Ziemeļi) nevarēja identificēt.

Otrs ĀCM skartais reģions bija Latvijas Vidzemes ziemeļos (2014. gada jūlijā), kas robežojas ar Igauniju. Iespējams, ka vīrusa izplatīšanos izraisīja nelikumīga cūku vai meža cūku blakusproduktu izmešana mežā. Pirmie pozitīvie saslimšanas gadījumi 2014. gada septembrī tika reģistrēti arī Igaunijā. Tika secināts, ka infekcija izplatījusies no Vidzemes reģiona Latvijā uz Igaunijas dienvidiem.

Trešais ĀCM skartais reģions bija Madona. Vīrusa ievazāšana, iespējams, notika jūlija vidū vai beigās, laikā, kad Latgales reģionā tika novērota paaugstināta vīrusa aktivitāte, tomēr joprojām nav skaidrs, kā ĀCM vīruss nonāca Madonā.

Latgales dienvidos un Vidzemē infekcija turpināja izplatīties, lēni un lokāli ar nemainīgi zemu prevalenci (zem 3 %).

2014. gadā ĀCM Latvijā tika apstiprināts 32 mājas cūku novietnēs, kurās bija 585 dzīvnieki. Uzraudzības ietvaros tika noņemti un izmeklēti 147 mājas cūku paraugi, no kuriem

69 dzīvniekiem bija pozitīvi rezultāti uz ĀCM vīrusu ar PCR metodi, savukārt septiņas cūkas bija gan seropozitīvas, gan PCR pozitīvas.

87,5 % tika klasificēti kā primārie uzliesmojumi, bet 12,5 % kā sekundārie saslimšanas gadījumi. 16 primāros saslimšanas gadījumus, visticamāk, izraisīja ēdiena atlieku izbarošana, bet 12 uzliesmojumus varēja saistīt ar aktīvo infekciju meža cūku populācijā. Sekundāros saslimšanas gadījumus izraisīja cilvēku kontakti starp novietnēm.

Kopā 2014. gadā meža cūkām tika apstiprināti 216 ĀCM gadījumi. 175 (71,4 %) no visiem pozitīvajiem, piederēja dzīvnieku grupai (n=245), kuri tika atrastas beigti (1. tabula).

Regions	Area size (infected counties)	Estimated WB density	Hunted WB	WB found dead	Cases
	km^2	(animals/km^2)	(PCR+) Prevalence	(PCR+) Prevalence	
Latgale-North	4166	2000 (0,5)	973 (2) 0,2%	10 (7) 70%	9
Latgale-South	2974	1800 (0,6)	838 (24) 2,9%	89 (60) 67,4%	84
Madona	2962	2000 (0,7)	290 (0)	24 (13) 54%	13
Vidzeme	2807	2000 (0,7)	666 (15) 2,3%	122 (95) 88%	110
Total	12,909	7800 (0,6)	2765 (41) 1,5%	245 (175) 71,4%	216

[a] One ASF case from the Alūksne region which is linked epidemiologically and geographically with cases in south Estonia is not included in this table.

1. tabula. ĀCM laboratorisko izmeklējumu rezultāti nomedītām un atrastām beigtām meža cūkām inficētajos Latvijas reģionos 2014. gadā (I.).

No 2765 nomedītajām meža cūkām 41 (1,7 %) bija PCR pozitīvas. Kopumā 24 (0,9 %) no 2475 testētajiem dzīvniekiem bija ĀCM antivielas; no kurām 14 bija arī PCR pozitīvas, bet 13 dzīvniekiem bija tikai antivielas.

3.2. ĀCM apkarošanas pasākumu un epidemioloģisko datu analīze (II)

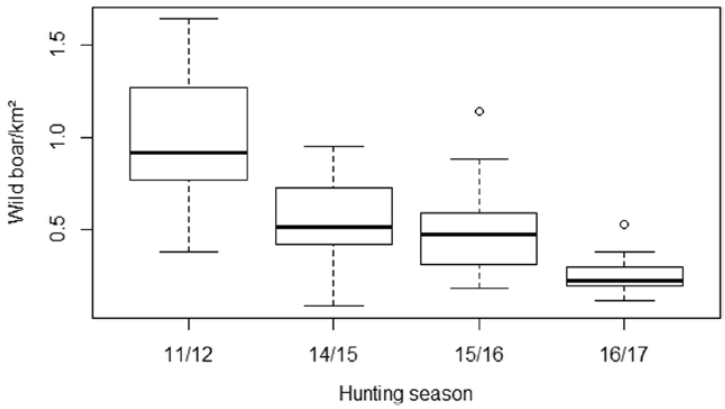
Par laika periodu no 25.06.2014. līdz 31.10.2017. (41 mēnesis) analīzei bija pieejami 12978 datu ieraksti. No tiem 5224 ieraksti bija no Latgales reģiona, 5379 no Vidzemes reģiona un 2375 no Madonas novada.

Tika konstatēta sakarība starp meža cūku vecumu un pozitīviem laboratorisko testu rezultātiem (gan ĀCMV genoma, gan seroloģijas). Analizējot visus paraugus, pozitīva testa rezultāta iespējamība bija lielāka jauniem dzīvniekiem. Varbūtība, ka paraugs, kas ņemts no beigta dzīvnieka, ir no jaunāka dzīvnieka, bija ievērojami lielāka salīdzinājumā ar vecākām meža cūkām. Varbūtība konstatēt pozitīvu testa rezultātu beigtām meža cūkām bija ievērojami lielāka nekā nomedītiem dzīvniekiem (2. tabula).

Age	ASFV genome detection	p	<0.001
		OR (95% CI)	0.55 (0.47–0.64)
	Serology	p	<0.001
		OR (95% CI)	0.72 (0.60–0.87)
	Carcass type (hunted/found dead)	p	<0.001
		OR (95% CI)	0.70 (0.60–0.82)
Carcass type (hunted/found dead)	ASFV genome detection	p	<0.001
		OR (95% CI)	192.51 (157.37–235.49)
	Serology	p	<0.001
		OR (95% CI)	9.30 (6.83–12.67)

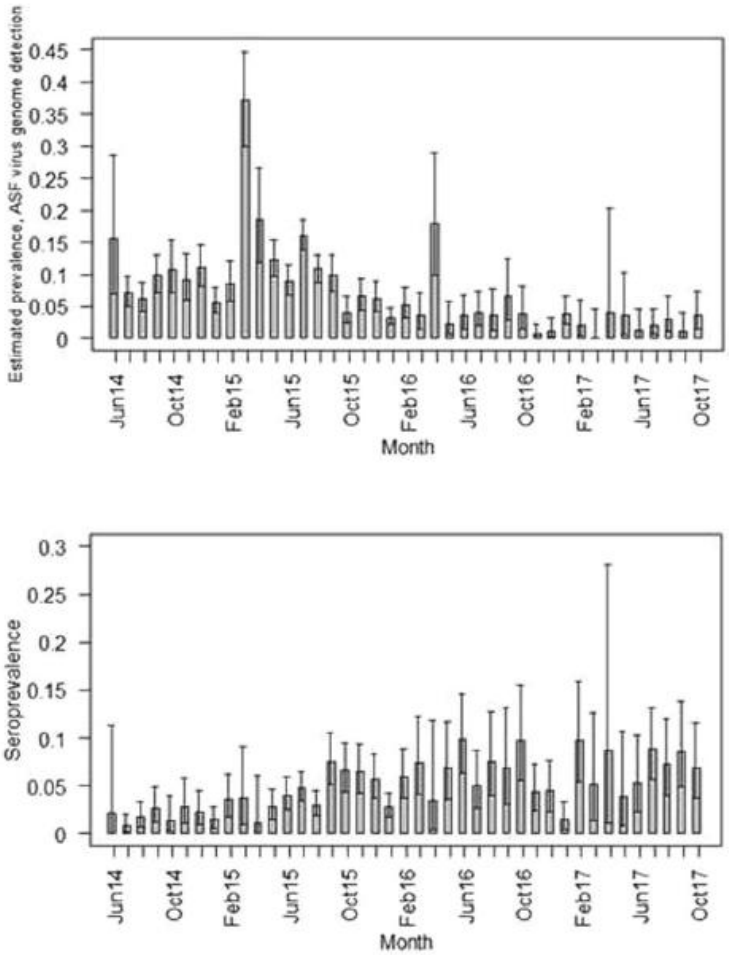
2. tabula. Sakarības starp potenciālajiem riska faktoriem ("vecumu un parauga veidu") un pozitīviem laboratorisko testu rezultātiem (ĀCMV genoma noteikšana un seroloģija) un sakarība starp vecumu un izmeklētā parauga veidu (II.).

Tika konstatētas īslaicīgas populācijas blīvuma izmaiņas: Salīdzinot ar 2011./2012. gada medību sezonu, meža cūku blīvums būtiski samazinājās, sākot no 2014. gada līdz 2016./2017. gada medību sezonai (p < 0,001) (8. attēls).



8. attēls. Meža cūku populācijas blīvuma izmaiņas laika gaitā (II.).

41 mēneša ilgajā pētījuma periodā ne ĀCM vīrusa prevalence, ne seroprevalence statistiski būtiski nemainījās (9. attēls).



9. attēls. Novērtētā ĀCMV prevalence (augšējā daļā — ĀCM vīrusa genoma noteikšana ar PCR; apakšējā daļā — ĀCM specifisko antivielu noteikšana). Stabiņi attēlo punktu novērtējumus, bet svītras — 95 % ticamības intervālus (II.).

Turpmākajai analīzei tika izvēlēti modeļi ar viszemāko Deviances informācijas kritērija (DIC) vērtību (3. tabula). Neviens no ĀCM kontroles un ierobežošanas pasākumiem neradīja būtisku ietekmi uz interesējošo mainīgo lielumu (atrastajiem beigto un nomedīto meža cūku paraugu proporcija vai novērtētā ĀCMV genoma prevalence).

Samaksa par katru atrastu beigtu meža cūku, lai motivētu paziņošanu (kontroles pasākums M1), deva lielāku ietekmi uz aplēsto ĀCMV genoma prevalenci (1,20) nekā vairums citu pasākumu. Tomēr starpība starp novērtēto prevalenci abos laika periodos bija gandrīz nulle. Arī atļauja izmantot klusinātājus un nakts redzamības ierīces meža cūku medībās (kontroles pasākums M5), šķiet, radīja lielāku, lai gan nebūtisku, ietekmi uz nomedīto meža cūku īpatsvaru un aplēsto ĀCMV genoma izplatību. Turklāt nomedīto meža cūku skaits bija lielāks laikposmā, kad tika īstenots kontroles pasākums M5.

Measure	Null hypotheses	Mean/ St.Dev.*
Incentives to all persons who report dead wild boar to the veterinary authorities (M1)	$H_0$1 No effect on the proportion of animals found dead	0.72
	$H_0$2 No effect on the estimated virus prevalence	1.20
Incentives to hunters for hunted wild boar (M2)	H_0 No effect on the proportion of hunted animals	0.65
Restrictions on driven hunts (M3a)	H_0 No effect on the estimated virus prevalence	0.61
Restrictions on driven hunts (M3b)	H_0 No effect on the estimated virus prevalence	0.58
Incentives for hunting adult and sub-adult female wild boar (M4a)	H_0 No effect on the proportion of hunted animals	0.09
Incentives for hunting adult and sub-adult female wild boar (M4b)	H_0 No effect on the proportion of hunted animals	0.78
Permission to use sound moderators (silencers) and night vision devices for wild boar hunting (M5)	$H_0$1 No effect on the proportion of hunted animals	1.71
	$H_0$2 No effect on the estimated virus prevalence	1.30

3. tabula. Daudzfaktoru analīžu rezultāti par kontroles pasākumu ietekmi uz ĀCMV genoma prevalences novērtējumu, kā arī uz medīto dzīvnieku vai atrasto mirušo dzīvnieku proporciju. *Vidējā vērtība/standartnovirze >1,96, kas norāda uz nozīmību statistiski (II.).

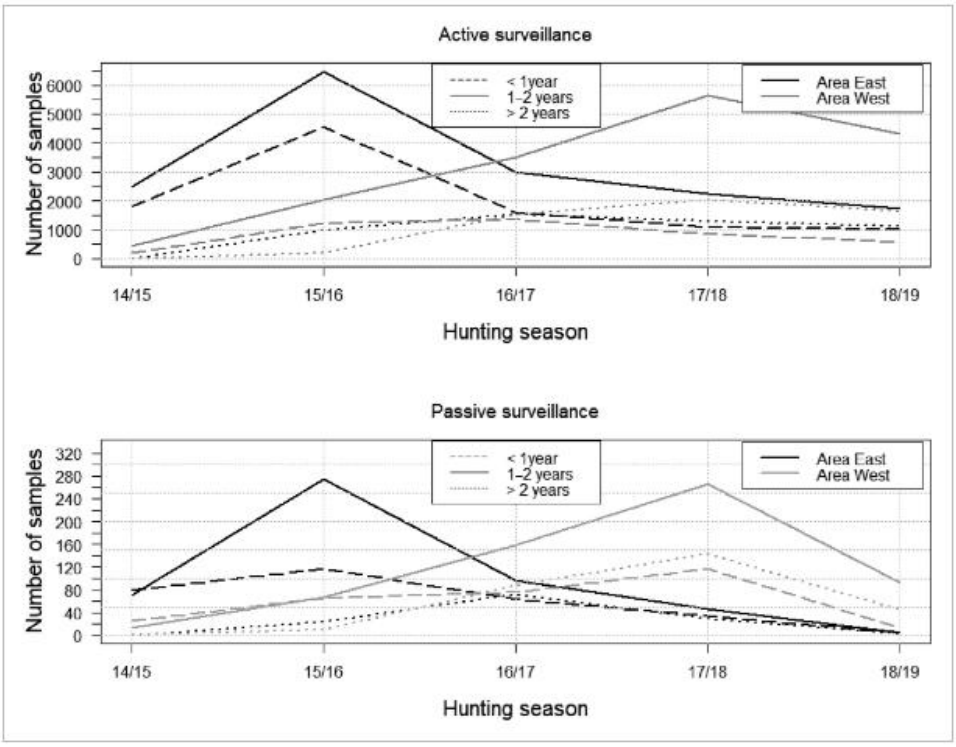
Maksājumi medniekiem, lai motivētu meža cūku medības (kontroles pasākums M2) statistiski nozīmīgi neietekmēja nomedīto dzīvnieku īpatsvaru, taču laikā, kad šis pasākums tika piemērots, nomedīto dzīvnieku skaits bija mazāks nekā laikā, kad tas netika piemērots.

Novērtētā ĀCMV genoma prevalence bija lielāka laikā, kad tika ierobežotas dzinējmedības (kontroles pasākumi M3a un M3b), salīdzinot ar laiku, kad dzinējmedības netika ierobežotas. Tomēr kontroles pasākuma M3 ietekme uz aprēķināto ĀCMV genoma prevalenci nebija būtiska. Arī maksājumi, lai motivētu medīt sivēnmātes (kontroles pasākums M4a un M4b) neuzrādīja statistiski nozīmīgu ietekmi uz nomedīto meža cūku īpatsvaru nevienā no periodiem, kuros tie tika piemēroti (3. tabula).

3.3. Pētījumā izmantoto uzraudzības datu raksturojums (III)

Analīzei tika izmantoti 60 166 datu ieraksti par izmeklēto meža cūku vecumu un laboratorisko izmeklējumu rezultātiem par laika periodu – no 2014. gada 1. aprīļa (2014/2015 medību sezonas) līdz 2019. gada 31. martam. Datu ieraksti, kuros nebija informācijas par vecumu, tika izņemti no vecuma analīzes (n = 1622).

Visos reģionos lielākā daļa paraugu tika ņemti no dzīvniekiem, kas bija vecumā no 1 līdz 2 gadiem. Aktīvajā uzraudzībā iegūto paraugu skaits bija ievērojami lielāks nekā pasīvajā uzraudzībā iegūto paraugu skaits (10. attēls).

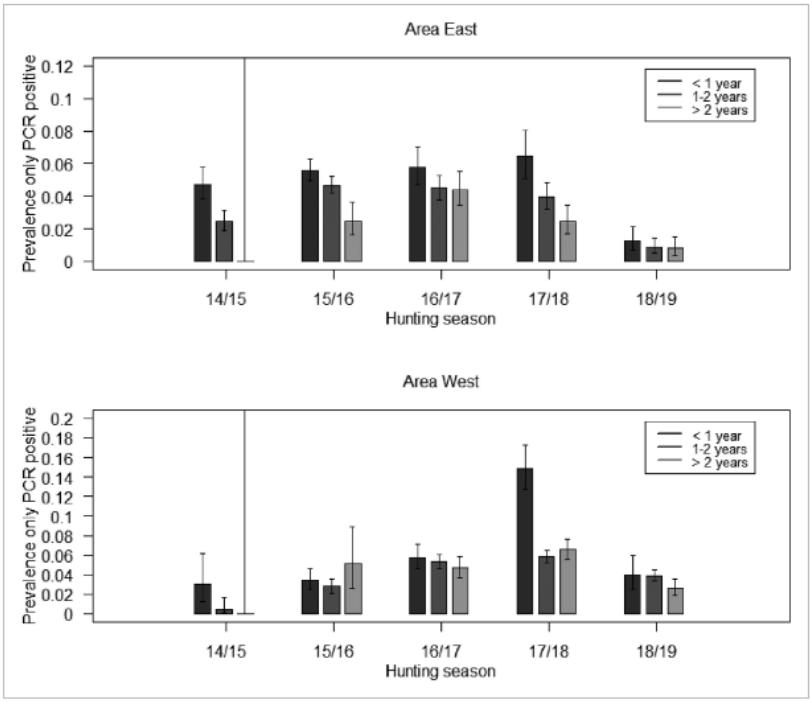


10. attēls. Paraugu skaits, kas iegūti aktīvās vai pasīvās uzraudzības ietvaros austrumu un rietumu reģionā, iedalīti trīs dažādās vecuma grupās (<1 gads, 1–2 gadi, >2 gadi) (III.).

Latvijas rietumu reģionos iegūto paraugu skaits bija nedaudz mazāks nekā austrumu reģionos, taču atšķirības paraugu lielumos nebija būtiskas. Austrumu apgabalā testēto meža cūku paraugu skaits sasniedza maksimumu 2015./2016. gada medību sezonā, savukārt Rietumu apgabalā paraugu skaits laika gaitā palielinājās un sasniedza maksimumu 2017./2018. gada medību sezonā (10. attēls).

3.4. Āfrikas cūku mēra laboratorisko izmeklējumu rezultātu analīze (III)

1. grupa. 1. grupā tika apkopoti visi paraugi ar PCR pozitīvu rezultātu uz ĀCMV neatkarīgi no seroloģiskā rezultāta (negatīvs, pozitīvs vai nav izmeklējuma). Gan austrumu, gan rietumu reģionos prevalence bija visaugstākā to dzīvnieku grupā, kuri bija jaunāki par 1 gadu (vidējā prevalence Austrumos: <1 gads: 0,048, 1-2 gadi: 0,033, >2 gadi: 0,020; vidējā prevalence rietumos: <1 gads: 0,063, 1-2 gadi: 0,037, >2 gadi: 0,037) (11. attēls). Šie rezultāti ir līdzīgi tiem, kas iegūti katrā atsevišķā pētījuma reģionā. .

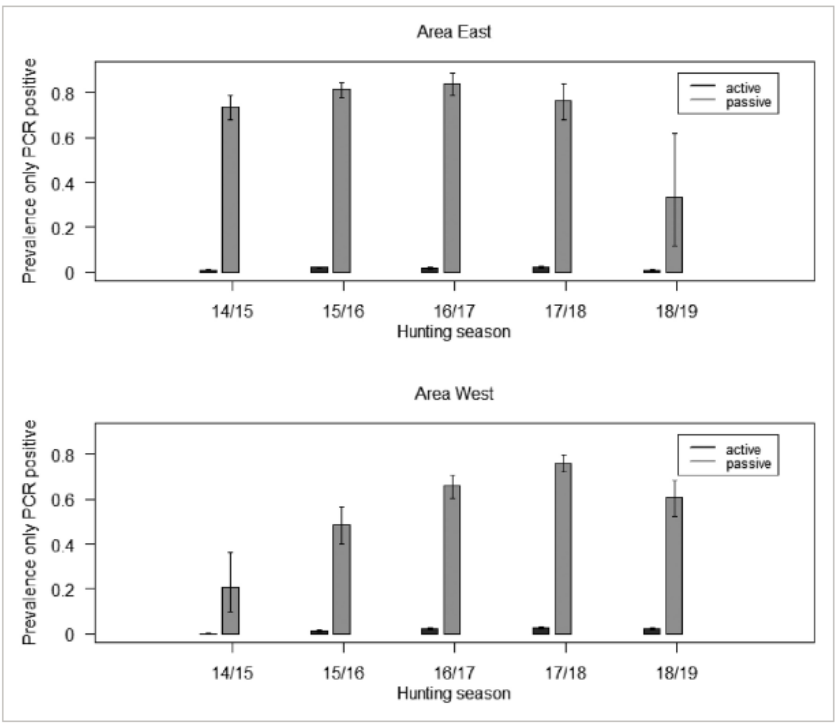


11. attēls. ĀCM PCR pozitīvo paraugu prevalences novērtējumi, neņemot vērā to seroloģisko testu rezultātus, sadalīti pēc vecuma grupām, pētījuma reģioniem (austrumiem un rietumiem) un medību sezonām. Līnijas norāda 95 % ticamības intervālus (III.).

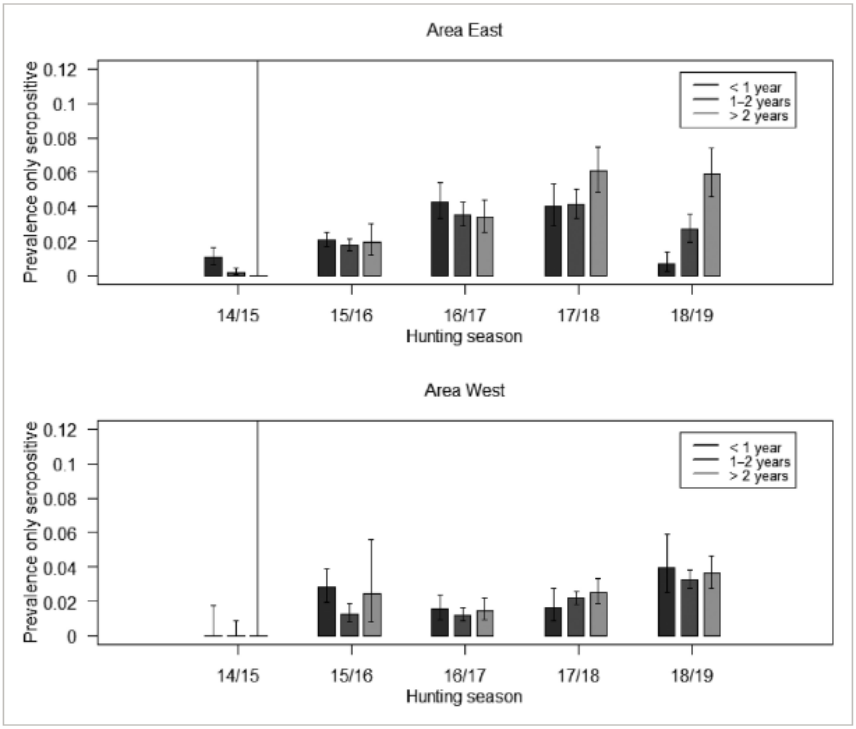
Abos pētījuma reģionos un visās medību sezonās nomedīto vai atrasto beigto meža cūku prevalences aprēķini, kas uzrādīja 1. grupai atbilstošus rezultātus, bija ievērojami augstāki (aptuveni 35 reizes augstāki) pasīvās uzraudzības ietvaros ņemtajiem paraugiem nekā aktīvās uzraudzības ietvaros ņemtajiem paraugiem (12. attēls).

2. grupa. 2. grupā apvienoja visus paraugus ar seropozitīvu un negatīvu PCR testa rezultātu uz ĀCMV. Atšķirībā no 1. grupas netika novērotas būtiskas atšķirības prevalences aprēķinos starp dažādām vecuma grupām, lai gan seropozitīvo dzīvnieku vidējā prevalence bija lielāka meža cūkām, kas vecākas par 2 gadiem (vidējā prevalence austrumos: <1 gads: 0,024, 1-2 gadi: 0,025, >2 gadi: 0,035; vidējā prevalence rietumos: <1 gads: 0,020, 1-2 gadi: 0,016, >2 gadi: 0.020). Tomēr, jo īpaši austrumos pēdējā medību sezonā, paraugi ar seropozitīvu rezultātu ievērojami biežāk tika iegūti dzīvniekiem, kas vecāki par 2 gadiem (<1 gads: 0,007 (KI: 0,003-0,014), 1-2 gadi: 0,027 (KI: 0,020-0,036), >2 gadi: 0,059 (KI: 0,046-0,074)) (13. attēls).

Arī austrumos seroprevalence sākotnēji palielinājās, taču, vēlāk, 2017/2018 un 2018/2019 medību sezonās, tika novērots samazinājums. Šī tendence tika novērota visās trīs vecuma grupās. Rietumos vidējā prevalence katrā vecuma grupā bija zemāka nekā austrumu reģionā. Tomēr laika gaitā arī rietumos tika novērots seroprevalences pieaugums (13. attēls).



12. attēls. ĀCMV PCR-pozitīvo paraugu prevalences novērtējumi, neatkarīgi no to seroloģisko testu rezultātiem, iedalīti pēc paraugu izcelsmes (aktīvā vai pasīvā uzraudzība), pētījuma reģioniem (austrumi un rietumi) un piecām medību sezonām. Līnijas norāda 95 % ticamības intervālus (III.).



13. attēls. ĀCM antivielu pozitīvo paraugu prevalences novērtējumi, iedalīti trīs dažādās vecuma grupās, pētījuma reģionos austrumos un rietumos, kā arī piecās medību sezonās. Līnijas norāda 95 % ticamības intervālus (III.).

3. grupa. 3. grupā tika analizēti visi paraugi ar pozitīvu PCR rezultātu uz ĀCMV un seropozitīvu testa rezultātu. Prevalences rādītāji 3. grupas medītiem dzīvniekiem bija ļoti zemi. Austrumu un rietumu apgabalos visaugstākā prevalence tika konstatēta paraugos, kas iegūti no dzīvniekiem, kuri jaunāki par 1 gadu (maksimālā prevalence 0,025). Abos reģionos prevalences novērtējumi bija līdzīgi. Uz novērojumu perioda beigām, t. i., 2018/2019. gada medību sezonā, tika novērots neliels samazinājums.

4. grupa. 4. grupā tika analizēti visi paraugi ar pozitīvu ĀCMV PCR un seronegatīvu testa rezultātu. Līdzīgi kā iepriekšējās grupās, visaugstākie prevalences rādītāji bija dzīvniekiem, kas jaunāki par 1 gadu. Tas galvenokārt attiecās uz Latvijas austrumu reģioniem (maksimālā prevalence 0,026). Līdzīgi kā 3. grupā, atšķirības prevalences rādītājos starp abiem pētījuma apgabaliem nebija būtiskas. Turklāt prevalences rādītāji laika gaitā samazinājās abos apgabalos.

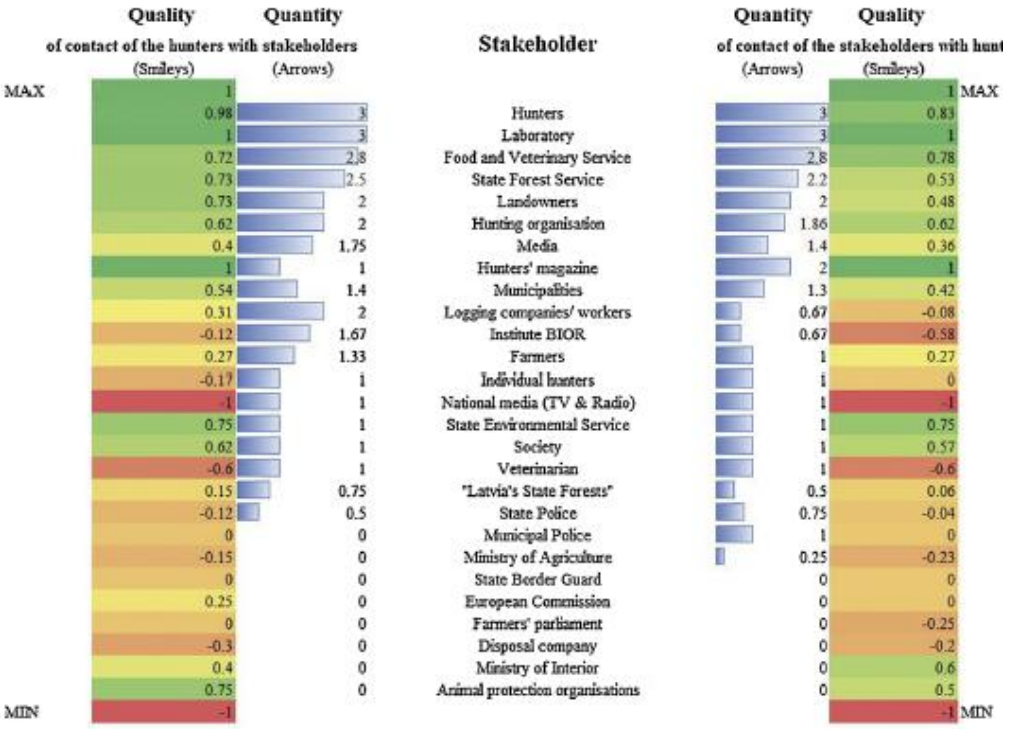
3.5. Mednieku iesaiste ĀCM kontrolē: līdzdalības epidemioloģijas pētījuma rezultāti (IV)

No 2019. gada aprīļa līdz jūlijam Latvijā tika organizētas kopumā 10 fokusgrupu diskusijas, katrā Latvijas statistiskajā reģionā – divas, tādējādi nodrošinot pilnīgu teritoriālo pārklājumu. Diskusijās kopumā piedalījās 50 dalībnieki (mednieki), no kuriem 49 bija vīrieši un 1 sieviete. Dalībnieku vidējais vecums bija 50 gadi. Dalībnieki kopumā identificēja 27 ĀCM kontrolē iesaistītās puses. Visas desmit fokusgrupas kā nozīmīgākās iesaistītās puses minēja Pārtikas un veterināro dienestu (PVD), VMD un pašvaldības. Astoņas grupas starp iesaistītajām pusēm nosauca arī medniekus, savukārt septiņas – mednieku organizācijas.

Trīs līdz piecas reizes tika pieminēti sabiedriskie mēdiji, zemes īpašnieki, Zemkopības ministrija (ZM), akciju sabiedrību "Latvijas valsts meži", Valsts policija, BIOR zinātnieki, lauksaimnieki, sabiedrība un mežizstrādes uzņēmumi. Blakusproduktu pārstrādes uzņēmumi tika minēti divas reizes. Vienu reizi tika pieminēts mednieku žurnāls, Iekšlietu ministrija, laboratorija, veterinārārsti, individuālie mednieki, Valsts robežsardze, Pašvaldības policija, Eiropas Komisija, valsts plašsaziņas līdzekļi (TV un radio), Zemnieku saeima, Valsts vides dienests un dzīvnieku aizsardzības organizācijas (14. attēls).

Stakeholder	Mentions by groups	Weighted average trust	Rank
Food and Veterinary Service	10	2.96	1
Hunters	8	2.84	2
Hunting organisation	7	1.83	3
State Forest Service	10	1.42	4
Hunters' magazine	1	0.99	5
Institute BIOR	3	0.97	6
Municipal administration	10	0.7	7
Ministry of Interior	1	0.68	8
Laboratory	1	0.68	8
Farmers	3	0.57	9
Landowners	4	0.41	10
Media	5	0.38	11
Society	3	0.29	12
Veterinarian	1	0.24	13
Ministry of Agriculture	4	0.2	14
Logging companies/ workers	3	0.14	15
"Latvia's State Forests"	4	0.13	16
State Police	4	0.05	17
Individual hunters	1	0	18
State Border Guard	1	0	18
Municipal Police	1	0	18
European Commission	1	0	18
National media (TV & Radio)	1	0	18
Farmers' parliament	1	0	18
State Environmental Service	1	0	18
Disposal company	2	0	18
Animal protection organisations	1	0	18

14. attēls. Desmit pētījumā iesaistīto grupu nosauktās ĀCM apkarošanas pasākumos iesaistītās puses, sakārtotas pēc mednieku uzticības tam, ka tās īsteno ĀCM kontroles pasākumus (IV.).



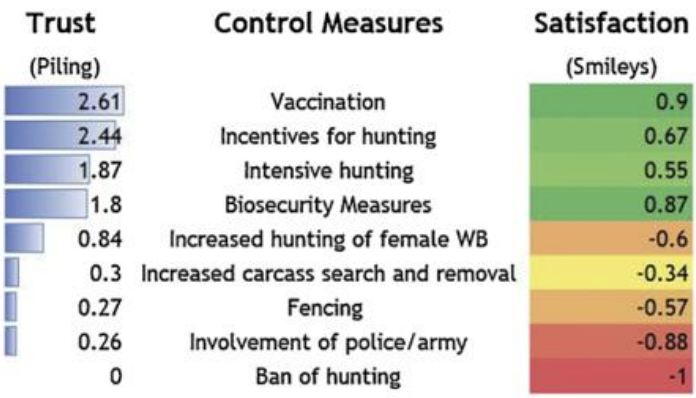
15. attēls. Pētījumā iesaistīto grupu uzskaitītās iesaistītās puses, sakārtotas pēc mednieku kontaktu biežuma un kontaktu kvalitātes (IV.).

Vislielāko uzticību dalībnieki pauda PVD, kam seko mednieki, mednieku organizācijas un VMD (14. attēls). Vislielākais dalībnieku kontaktu skaits (kvantitāte) bija ar citiem medniekiem un procesā iesaistītajām pusēm, t. i., BIOR laboratoriju, PVD, VMD, mednieku organizācijām un pašvaldību administrācijām (15.attēls). Kontaktu kvalitāte bija augstāka tām iesaistītajām pusēm, ar kurām bija regulāri kontakti. Mednieki izteica vēlmi vairāk komunicēt ar iestādēm, lai varētu paust savu viedokli un dalīties pieredzē.

No visiem ĀCM kontroles pasākumiem vakcinācija bija vislabāk pieņemtais pasākums, kas saņēma arī visaugstāko apmierinātības novērtējumu, kam sekoja medību veicināšanas pasākumi, intensīvas medības un biodrošības pasākumi. Pastiprinātas sivēnmāšu medības guva zemāku uzticības novērtējumu, un dalībnieki tās neuzskatīja par vēlamām. Žogu ierīkošana, policijas vai armijas iesaistīšana un medību aizliegums bija kontroles pasākumi, kuriem mednieki uzticējās vismazāk, un tie saņēma viszemāko apmierinātības vērtējumu (16. attēls). Citi vērtējumā iekļautie kontroles pasākumi, kas tika minēti tikai trīs reizes vai mazāk, bija, piemēram, mednieku izglītošana par visiem ar ĀCM saistītiem jautājumiem, dažādas medību metodes, sabiedrības piekļuves ierobežošana platībām, kurās konstatētas ar ĀCM inficētas meža cūkas, indēšana un putnu vai sīko plēsēju medības.

Mednieki uzskatīja, ka izdevumus, kas medniekiem rodas, piedaloties ĀCM kontroles pasākumos, ir jākompensē. Tomēr, medības, kuras motivē tikai nauda, tika uzskatītas par neētiskām. Izglītošana un biodrošības uzlabošana samazinātu ĀCM izplatību. Pastiprinātas sivēnmāšu medības tika uzskatītas par piemērotu pasākumu meža cūku populācijas samazināšanai, bet ne par uzticamu ĀCM ierobežošanā. Turklāt tā īstenošana netika atbalstīta medību ētikas apsvērumu dēļ, jo īpaši atnešanās un zīdīšanas sezonas laikā. Medības ārpus atnešanās sezonas ir pieņemamākas. Mednieki izteica bažas, ka policijas vai armijas iesaistīšana medībās un pastiprinātas mātīšu medības varētu izraisīt ĀCM izplatīšanos, nevis tā kontroli. Turklāt dalībnieki pauda bažas, ka policija vai armija varētu nogalināt meža cūkas nepiemērotā vai neētiskā veidā.

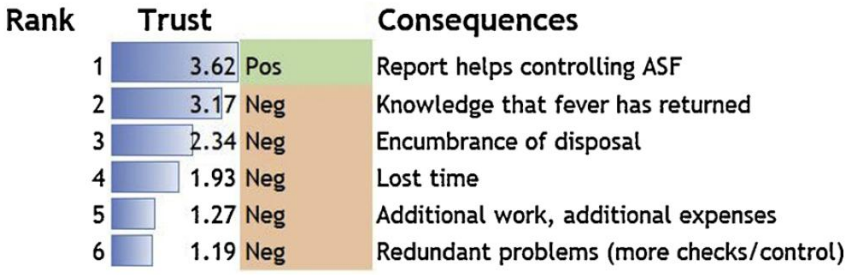
Attiecībā uz pasīvo uzraudzību mednieki minēja 31 iespējamās sekas. Lai gan vairākas grupas nespēja nosaukt nevienu pozitīvu pasīvās uzraudzības seku piemēru, ziņošana par beigto meža cūku līķiem bija uzskatāma par pozitīvu rīcību, jo tā var palīdzēt kontrolēt ĀCM. Visas pārējās pasīvās uzraudzības sekas tika uzskatītas par negatīvām (17. attēls). Fokusgrupu diskusijās tika pieminēts pašaizliedzīgs pienākums un mednieku ieinteresētība darīt visu, kas ir viņu spēkos, lai kontrolētu ĀCM. Tika identificētas vairākas problēmas, tostarp papildu darbs, laika patēriņš un meža cūku līķu aprakšanas izmaksas.



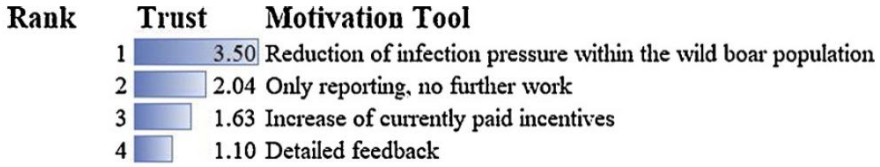
16. attēls. Kontroles pasākumi, kurus identificēja vismaz četras no desmit pētījumā iesaistītajām grupām, sakārtoti atbilstoši uzticēšanās līmenim to efektivitātei ĀCM ierobežošanā un mednieku apmierinātībai ar šo pasākumu īstenošanu (IV.).

Dalībnieki minēja, ka sākoties ĀCM epidēmijai viņi jutušies šokēti, kad saskarušies ar pienākumiem, ko viņiem uzlika valsts noteikumi un rīkojumi. Trūka informācija par veicamajiem pasākumiem un mežā aprakt meža cūku līķus bez palīdzības vai atbilstošiem tehniskiem līdzekļiem, bija apgrūtinoši. Dalībnieki uzskatīja, ka pašreizējā finansiālā kompensācija ir nepietiekama, jo laiku, kas viņiem jāvelta attiecīgajām darbībām varētu izmantot veicot ienesīgākas darbības, vai laiku pavadot kopā ar ģimeni.

Iespējamais infekcijas izplatības samazinājums meža cūku populācijā tika uzskatīts par lielāko motivāciju. Tam sekoja pašreizējās darba slodzes samazināšana, aprobežojoties tikai ziņošanai par beigtām meža cūkām, pašlaik izmaksājamās kompensācijas palielināšana un detalizēta atgriezeniskā saite par konstatēto meža cūku veselības stāvokli (18. attēls).



17. attēls. Pasīvās uzraudzības uztvertās sekas, kuras minēja vismaz trīs pētījumā iesaistītās grupas, sakārtotas pēc to vidējā rādītāja, kas aprēķināts, balstoties uz stikla lodīšu sadalījumu atbilstoši to uztvertajai ietekmei uz medniekiem (IV.).



18. attēls. Motivācijas līdzekļi, kas sarindoti pēc piešķirto stikla lodīšu vidējā skaita, atbilstoši to uztvertajai ietekmei uz mednieku vēlmi iesaistīties pasīvajā uzraudzībā (IV.).

Diskusijās mednieki paskaidroja, ka viņi uzskata, ka viņu pienākums ir mazināt infekcijas izraisīto ietekmi uz meža cūku populāciju. Turklāt tika minētas grūtības bez palīdzības aprakt līķus un bailes kaut ko izdarīt nepareizi. Apspriežot motivācijas līdzekļus, dalībnieki izteica divus ierosinājumus: i) izveidot profesionālu grupu līķu aizvākšanai, paraugu ņemšanai un apbedīšanai un ii) ieprogrammēt viedtālruņu lietotni, ko iedzīvotāji vai mednieki varētu izmantot, lai ziņotu par atrasto līķu koordinātēm un augšupielādētu attēlus.

4. DISKUSIJA

4.1. ĀCM izplatības tendences un dinamika Latvijas meža cūku populācijā (I, II, III)

Neskatoties uz ilgstoši īstenotajiem kontroles pasākumiem, ĀCM jau divpadsmit gadus saglabājas un izplatās Latvijas meža cūku populācijā. Vienlaikus rezultāti norāda uz endēmiskai stabilitātei raksturīgu situāciju, kurā vīruss turpina cirkulēt zemā intensitātē bioloģiski un ekoloģiski noturīgā veidā (III). Lai novērtētu epidemioloģisko situāciju un nodrošinātu efektīvu slimības uzraudzību un kontroli, nepieciešama sistemātiska uzraudzības sistēma. Līdzīgi novērojumi aprakstīti arī Igaunijā (Nurmoja et al., 2017), kas apliecina nepieciešamību saglabāt efektīvu uzraudzību ne tikai pēc, bet arī pirms slimības apstiprināšanas konkrētā teritorijā.

Schulz et al. (2019), kā arī II un III pētījuma publikācijas norāda, ka novērotais meža cūku populācijas samazinājums pētījuma periodā, visticamāk, ir saistīts gan ar ĀCMV izraisīto augsto letalitāti meža cūkām, gan ar aktīvāku populācijas regulēšanu medību ceļā. Kā norāda Andersone-Lilley et al. (2010) un Kawata et al. (2013), meža cūku populācijai Latvijā, Baltijā un daudzviet citās Eiropas valstīs kopš pagājušā gadsimta sešdesmitajiem gadiem bija raksturīga pieaugoša tendence. Saskaņā ar VMD dzīvnieku uzskaites datiem meža cūku skaits Latvijā samazinājās no aptuveni 74 000 dzīvnieku 2013. gadā līdz aptuveni 20 000 dzīvnieku 2018./2019. medību sezonas beigās, kas atbilst populācijas samazinājumam par aptuveni 73 %. Populācijas blīvuma samazināšanās un līdz ar to arī konstatēto meža cūku līķu skaita mazināšanās varētu liecināt, ka epidēmijas fāze tuvojas noslēgumam (Guberti et al., 2022; European Commission, 2023). Tomēr, kamēr ĀCM nav pilnībā izskausts, jāturpina efektīva populācijas pārvaldība un uzraudzība, kā to uzsver arī EFSA (2020).

Veiktajā pētījumā tika pieņemts, ka meža cūkas pēc inficēšanās ar ĀCM kļūst PCR pozitīvas dažas dienas pēc inficēšanās. Aptuveni 7–10 dienu laikā attīstās arī antivielas pret ĀCMV. Tiek uzskatīts, ka PCR pozitivitāte kopā ar antivielu klātbūtni asinīs var saglabāties līdz aptuveni 100 dienām pēc inficēšanās, savukārt pēc tam dzīvnieki var saglabāt tikai antivielas nenoteiktu laiku (Arias et al., 2017; Petrov et al., 2018; Zani et al., 2018; II, III). Pamatojoties uz šo pieņēmumu, laboratorisko izmeklējumu rezultāti tika analizēti vairākās grupās, pieņemot, ka 1. grupas dzīvnieki bija inficēti pēdējo 100 dienu laikā pirms paraugu ņemšanas, savukārt 2. grupas dzīvnieki bija izdzīvojuši pēc ĀCM infekcijas (III). Jāņem vērā, ka atrasto dzīvnieku līķi bieži atradās sadalīšanās stadijā, tādēļ no tiem nebija iespējams iegūt asins paraugus, un pasīvās uzraudzības laikā iegūtie paraugi parasti netika testēti uz antivielām pret ĀCMV (I, III).

Gan Latvijā (III), gan Igaunijā (Schulz et al., 2019) tika novērotas līdzīgas epidemioloģiskās tendences — pēc sākotnēja pieauguma, kā to aprakstīja Depner et al. (2017),

laika gaitā samazinājās ĀCMV prevalence un pieauga seroprevalence nomedītajās meža cūkās. Līdzīgas tendences aprakstījusi arī EFSA (2020), norādot, ka reģionos ar ilgstošu ĀCM cirkulāciju samazinās ASFV genoma prevalence, vienlaikus pieaugot seropozitīvo dzīvnieku īpatsvaram. Turklāt, līdzīgi kā Igaunijā, 1. un 2. grupas prevalences novērtējumu atšķirības starp medību sezonām liecināja par laika nobīdi starp Latvijas austrumu un rietumu reģioniem.

Abu prevalenču rādītāji laika gaitā bija salīdzināmi, tomēr seroprevalences pieaugums Latvijas rietumu daļā notika vēlāk. Latvijas austrumos seroprevalence jaunākajās vecuma grupās samazinājās no 4,1–4,3 % 2017./2018. medību sezonā līdz 0,7–2,7 % 2018./2019. sezonā, savukārt Latvijas rietumos tajā pašā laikā seroprevalence sasniedza augstāko līmeni – 3,3–3,9 %, tai skaitā maksimumu 3,93 %, norādot uz vēlīnāku epidēmijas attīstības stadiju. Latvijas austrumos seroprevalence sāka samazināties 2018./2019. medību sezonā, kas kopā ar ļoti zemo ĀCMV prevalenci pētījuma perioda beigās varētu liecināt par slimības izskaušanas procesa sākumu šajā reģionā, savukārt rietumos seroprevalence tajā pašā sezonā sasniedza maksimumu, norādot uz vēlīnāku epidēmijas samazināšanās fāzi. Slimības gaitu var izskaidrot ar lēnu ĀCM izplatīšanos no Latvijas austrumiem uz rietumiem, un tā kopumā ir līdzīga EFSA (2020) aprakstītajām tendencēm Latvijā un Igaunijā. Pieņēmumu papildus apstiprina EFSA (2020) dati, kas liecina, ka 2020. gadā no 106 Latvijā konstatētajām ASFV pozitīvajām meža cūkām 103 tika konstatētas valsts rietumu daļā, savukārt austrumu reģionā tika identificēti tikai trīs ASFV pozitīvi dzīvnieki. Ļoti zema ĀCMV prevalence Latvijas austrumos un seroprevalences samazināšanās pētījuma perioda beigās var liecināt par lēnu ĀCM izplatības samazināšanos vai pat izzušanu (III).

Secinājumus apstiprina 3. un 4. grupas prevalences analīze, ietverot paraugus no nesen inficētiem medītiem dzīvniekiem, kas inficējušies pēdējo 100 dienu laikā pirms paraugu ņemšanas. Prevalences rādītāji laika gaitā samazinājās, austrumos nedaudz ātrāk nekā rietumos. Abās teritorijās prevalences rādītāji bija ļoti zemi un nepārsniedza aptuveni 2–2,5 %, bet augstākie rādītāji tika novēroti meža cūkām, kas jaunākas par vienu gadu. ĀCMV PCR pozitīvo paraugu prevalence (1. grupa) sasniedza visaugstāko līmeni tieši šajā vecuma grupā – 4,8 % Austrumu un 6,3 % Rietumu reģionā, savukārt vecākajās vecuma grupās prevalence nepārsniedza 2–3 %. Iegūtie rezultāti atbilst EFSA (2015) secinājumiem, norādot, ka ĀCMV prevalences rādītāji bija visaugstākie dzīvniekiem, kas jaunāki par vienu gadu.

Tāpat konstatēts, ka dzīvnieku PCR pozitīvo paraugu prevalence bija būtiski augstāka, ja paraugi tika iegūti no beigtiem dzīvniekiem, t. i., pasīvās uzraudzības ietvaros, salīdzinot ar aktīvo uzraudzību – nomedītām klīniski veselām meža cūkām. Pasīvās uzraudzības ietvaros prevalence svārstījās no 20 % līdz 84 %, savukārt aktīvās uzraudzības ietvaros tā pārsvarā bija

robežās no 1 % līdz 4 %. Tādējādi pozitīva rezultāta konstatēšanas iespējamība pasīvās uzraudzības ietvaros bija no piecām līdz pat 35 reizēm augstāka nekā aktīvās uzraudzības laikā iegūtajos paraugos. Atšķirība bija īpaši izteikta jauno dzīvnieku vecuma grupā, kur prevalence pasīvās uzraudzības ietvaros ņemtajiem paraugiem bija līdz pat 35 reizēm augstāka. Iegūtie dati vēlreiz uzsver būtisko atšķirību starp ĀCM pasīvās uzraudzības ietvaros izmeklētajiem paraugiem no mirušām meža cūkām un aktīvās uzraudzības ietvaros iegūtajiem paraugiem no nomedītām meža cūkām. Mūsu rezultātos novērotās tendences Latvijā (I, II, III) ir līdzīgas Nurmoja et al. (2017) pētījumiem Igaunijā, kā arī EFSA aprakstītajiem novērojumiem (EFSA, 2018). Abus novērojumus var skaidrot ar ĀCM augsto letalitāti, kas sasniedz 90–100 %, tādēļ lielākā daļa inficēto dzīvnieku tiek identificēti tieši pasīvās uzraudzības ietvaros (II, III).

Savukārt ievērojami augstāki seroprevalences rādītāji medītiem dzīvniekiem, kas vecāki par diviem gadiem (2. grupa), pēdējās divās medību sezonās Latvijas austrumu reģionā varētu būt saistīti ar pārslimojušo meža cūku īslaicīgu akumulēšanos populācijā un ĀCMV izplatības samazināšanos Latvijas austrumu daļā (II; EFSA, 2020; III). Vairākos iepriekšējos pētījumos plaši apspriesta ĀCM pārslimojušo dzīvnieku loma un to iespējamā nozīme slimības izplatībā (EFSA, 2015; Gallardo et al., 2018; Petrov et al., 2018; II), taču līdz šim nav iegūti pārliecinoši pierādījumi, ka seropozitīvas, bet PCR negatīvas meža cūkas būtu epidemioloģiski nozīmīgs infekcijas avots (Ståhl et al., 2019; III; Oļševskis et al., 2023). Tādēļ nepārtraukta seropozitīvu dzīvnieku atklāšana neliecina par jaunu vīrusa izplatīšanos, bet drīzāk atspoguļo epidēmijas mazināšanos. Šis visaptverošais pēdējo piecu gadu Latvijas uzraudzības datu raksturojums dod pamatu piesardzīgam optimismam par veiksmīgu ĀCM kontroli vai pat potenciālu izskaušanu meža cūku populācijā.

4.2. ĀCM uzraudzības sistēmas principi meža cūku populācijā (I, II, III, IV)

ĀCM uzraudzība Latvijā balstās uz diviem galvenajiem komponentiem – aktīvo uzraudzību, kas ietver nomedītu meža cūku paraugu laboratorisko izmeklēšanu, un pasīvo uzraudzību, kas balstās uz atrasto beigto dzīvnieku ziņošanu un to laboratorisko izmeklēšanu. Iegūtie rezultāti apliecina, ka pasīvā uzraudzība ir epidemioloģiski jutīgāks un efektīvāks instruments ĀCMV noteikšanā, īpaši teritorijās ar zemu slimības izplatību. Latvijas pētījumos PCR pozitīvo paraugu prevalence pasīvās uzraudzības ietvaros sasniedza 20–84 %, savukārt aktīvajā uzraudzībā tā pārsvarā nepārsniedza 1–4 % (I; II; III). Līdzīgas tendences novērotas arī Eiropas Savienības līmenī. EFSA ziņojumos norādīts, ka Baltijas valstīs un Polijā atrastajām beigtajām meža cūkām konstatētā ĀCMV prevalence sasniedza 60–86 %, kamēr nomedītajām meža cūkām tā bija tikai 0,04–3 % robežās (EFSA, 2017; 2018).

Pētījumā konstatētās sakarības starp riska faktoriem un laboratorisko testu rezultātiem kopumā atbilst citu valstu pieredzei. Piemēram, Igaunijā, neraugoties uz to, ka lielākā daļa paraugu (60 238 jeb 95,7 %) tika iegūti aktīvās uzraudzības ietvaros, būtiski augstāka ĀCMV prevalence (60–86 %). tika konstatēta tieši pasīvās uzraudzības paraugos (Nurmoja et al., 2017). Līdzīgus secinājumus izdarījis arī Smietanka et al. (2016), norādot, ka atrastās beigtās meža cūkas ir epidemioloģiski vērtīgākais informācijas avots ĀCM agrīnai noteikšanai un slimības izplatības raksturošanai. Tā kā līdzīgas epidemioloģiskās tendences konstatētas vairākās valstīs, kurās ĀCM cirkulē meža cūku populācijā, var secināt, ka riska faktori, kas nosaka ĀCM pozitīva parauga atklāšanas varbūtību, ir relatīvi līdzīgi neatkarīgi no reģiona, populācijas blīvuma vai vides apstākļiem. Tas liecina, ka ĀCM epidemioloģiskā attīstība meža cūku populācijās dažādās skartajās teritorijās lielā mērā ir salīdzināma (II).

Vienlaikus jāatzīmē, ka pasīvās uzraudzības efektivitāti būtiski ietekmē iespēja savlaicīgi atrast un izmeklēt beigtās meža cūkas. Praktiskās grūtības atrast meža cūku līķus dabā izskaidro, kāpēc pētījuma periodā pasīvās uzraudzības ietvaros tika iegūti tikai 8,2 % paraugu, kamēr aktīvās uzraudzības ietvaros tika izmeklēti 91,8 % (I). Tomēr, neraugoties uz ievērojami mazāko paraugu skaitu, pasīvā uzraudzība nodrošināja būtiski augstāku infekcijas noteikšanas varbūtību, apliecinot tās augsto informatīvo vērtību slimības agrīnā atklāšanā un epidemioloģiskās situācijas raksturošanā.

Lai gan pasīvā uzraudzība ir jutīgākais ĀCM noteikšanas instruments, efektīvai slimības pārvaldībai nepieciešama abu uzraudzības komponentu savstarpēji papildinoša darbība. Savukārt ilgtermiņā meža cūku populācijas blīvums būtu jāuztur pēc iespējas zemāks, lai mazinātu ĀCM pārneses intensitāti un ierobežotu vīrusa cirkulāciju populācijā, kā norādīts gan eksperimentālajos, gan epidemioloģiskajos pētījumos (Gavier-Widén et al., 2015; Lange, 2015; EFSA, 2018; 2020). Vienlaikus nepieciešams uzturēt efektīvu un uzticamu uzraudzības sistēmu, kas ļautu savlaicīgi identificēt izmaiņas epidemioloģiskajā situācijā un operatīvi pielāgot kontroles pasākumus.

4.3. Latvijā ieviesto ĀCM kontroles pasākumu efektivitāte meža cūku populācijā (II, IV)

Latvijā ĀCM kontrole meža cūku populācijā balstās uz vairāku pasākumu kopumu, kur viens no būtiskākajiem ir populācijas samazināšanas stratēģija, palielinot medību intensitāti un īpaši veicinot sivēnmāšu nomedīšanu (II).

Tomēr pieejamie pētījumu rezultāti liecina, ka tradicionālās (rekreācijas) medības nav pietiekamas, lai būtiski samazinātu meža cūku populācijas blīvumu un ilgtermiņā kontrolētu slimību epidemioloģiskos riskus. Neselektīvas un telpiski fragmentētas medības var saglabāt

augstu populācijas reproduktīvo potenciālu un atsevišķos gadījumos pat veicināt populācijas atjaunošanos, izjaucot sociālo struktūru un stimulējot intensīvāku vairošanos (Massei et al., 2015; Pepin et al., 2017; Gortázar et al., 2026). Tādēļ efektīvai populācijas pārvaldībai nepieciešamas koordinētas un mērķētas kontroles stratēģijas, īpašu uzmanību pievēršot reproduktīvo mātīšu izņemšanai un populācijas struktūras regulēšanai (Massei et al., 2015).

Līdzīgi secinājumi izriet arī no Latvijā veiktajiem pētījumiem par ĀCM epidemioloģiju meža cūku populācijā. Analizējot slimības izplatību un populācijas dinamiku pēc ĀCM ieviešanās 2014. gadā, tika konstatēts, ka slimības persistenci lielā mērā nosaka vides rezervuāri, īpaši inficētie meža cūku līķi, kas nodrošina ilgstošu vīrusa cirkulāciju populācijā (I, III). Šie rezultāti norāda, ka populācijas samazināšana ar medību palīdzību vien nav pietiekama, ja vienlaikus netiek īstenoti arī citi kontroles pasākumi, piemēram, pasīvās uzraudzības stiprināšana, intensīva līķu meklēšana un iznīcināšana (Massei et al., 2015; Malmsten et al., 2017; Pepin et al., 2017; EFSA , 2020; Bartoš et al., 2021).

Iegūtie rezultāti liecina, ka līdz šim ieviestie pasākumi nav būtiski samazinājuši ĀCM izplatību (II). Viens no galvenajiem iemesliem ir meža cūku augstā reproduktīvā kapacitāte, kas ļauj populācijai relatīvi ātri atjaunoties (Malmsten et al., 2017; Pepin et al., 2017; Bartoš et al., 2021). Turklāt medību radītās sociālās struktūras izmaiņas var palielināt dzīvnieku pārvietošanos un kontaktu intensitāti, tādējādi potenciāli veicinot slimības izplatīšanos (Massei et al., 2026).

Izvēloties kontroles pasākumus, būtu jāatsakās no neselektīvas populācijas samazināšanas kā vienīgā risinājuma un jākoncentrējas uz mērķtiecīgiem, ekoloģiski pamatotiem pasākumiem. Tie ietver lokālu subpopulāciju kontroli, reproduktīvo mātīšu mērķētu izņemšanu, medību intensitātes pielāgošanu atbilstoši sezonālajai reproduktīvajai aktivitātei, kā arī lēmumu pieņemšanu, balstoties uz aktuāliem epidemioloģiskajiem un populācijas uzskaites datiem (II, IV).

Kopumā rezultāti norāda, ka efektīva ĀCM kontrole meža cūku populācijā ir iespējama tikai ar integrētu pieeju, apvienojot populācijas pārvaldību, pasīvo uzraudzību un ĀCMV vides rezervuāru kontroli.

4.4. Meža cūku bioloģiskie un ekoloģiskie faktori, kas ietekmē ĀCM izplatību un veicina vīrusa noturību populācijā (I, II, III)

Meža cūku līķi joprojām ir viens no galvenajiem vīrusa rezervuāriem un izplatīšanās faktoriem. ĀCMV spēja saglabāt dzīvotspēju meža cūku līķos nedēļām vai pat mēnešiem, īpaši ziemā (Alonso et al., 2018; WOAH 2019), veicina netiešu vīrusa pārnesi ar dzīvnieku līķu

starpniecību. Tādējādi līķu savākšana un droša aizvākšana ir bioloģiski kritisks, taču loģistikas ziņā sarežģīts kontroles pasākums. Saskaņā ar EFSA (2020) uzraudzības datiem un epidemioloģiskās modelēšanas rezultātiem, vīrusa pārnese ar līķu starpniecību var būt epidemioloģiski nozīmīgāka nekā tiešs dzīvnieku kontakts, uzturot ĀCMV cirkulāciju meža cūku populācijā; līdzīgi secinājumi izriet arī no šī pētījuma rezultātiem (I; III).

ĀCMV noturību populācijā ietekmē arī meža cūku bioloģiskās īpašības. Augstā reproduktīvā kapacitāte, spēja relatīvi ātri atjaunot populāciju, kā arī sociālās struktūras izmaiņas, ko izraisa intensīvas medības, rada apstākļus, kuros vīruss var saglabāties ilgstoši. Neselektīva vai telpiski fragmentēta populācijas samazināšana var saglabāt augstu reproduktīvo potenciālu un noteiktos apstākļos pat veicināt populācijas atjaunošanos, tādējādi apgrūtinot ilgtermiņa slimības kontroli (Massei et al., 2015; Pepin et al., 2017; Gortázar et al., 2026).
Šajā kontekstā svarīgs ir arī vecuma struktūras aspekts. ĀCMV PCR pozitīvie paraugi visaugstāko prevalenci (14,9%) sasniedza meža cūkām, kas jaunākas par vienu gadu, savukārt seroprevalence bija augstākā (5,8%) vecākiem dzīvniekiem (III). Tas liecina, ka jaunākie dzīvnieki biežāk iet bojā akūtas infekcijas laikā, savukārt vecākajās vecuma grupās uzkrājas indivīdi, kas, iespējams, ir izdzīvojuši pēc inficēšanās. Tomēr, kā uzsver Stahl et al. (2019) un Oļševskis et al. (2023) līdzšinējie pētījumi nesniedz pārliecinošus pierādījumus, ka seropozitīvi, bet PCR negatīvi dzīvnieki būtu epidemioloģiski nozīmīgi ilgtermiņa infekcijas uzturētāji, un šis secinājums sakrīt arī ar šī darba rezultātiem (III).

Kopumā bioloģisko un ekoloģisko faktoru kopums norāda, ka ĀCM noturība meža cūku populācijā nav skaidrojama tikai ar tiešu ĀCMV pārnesi starp dzīvniekiem. Būtiska nozīme ir vides rezervuāriem, populācijas blīvumam, vecuma struktūrai, reproduktīvajam potenciālam un populācijas kontrolei ar medību palīdzību, tādēļ slimības kontrolei nepieciešama integrēta pieeja, kas vienlaikus ņem vērā gan epidemioloģiskos, gan ekoloģiskos mehānismus (I, II, III).

4.5. Mednieku loma, motivējošie faktori, un to ietekme uz slimības kontroles pasākumu efektivitāti (I, II, III, IV)

Latvijā līdzdalības epidemioloģijas metode tika pielietota pirmo reizi. Neraugoties uz šīs pieejas potenciālu iesaistīt galvenās ieinteresētās puses slimību uzraudzības un kontroles programmu izstrādē, attīstītajās valstīs tā epidemioloģiskajos pētījumos līdz šim izmantota salīdzinoši reti (Catley et al., 2012; Calba et al., 2014; 2015; Schulz et al., 2016).

Latvijā veiktie līdzdalības pētījumi ar mednieku iesaisti apliecina, ka mednieki ir būtisks slimības uzraudzības un populācijas pārvaldības sistēmas elements, nodrošinot gan meža cūku populācijas regulēšanu, gan nozīmīgu ieguldījumu pasīvajā uzraudzībā (IV). Vienlaikus Tomēr

efektīvai slimības kontrolei nepieciešama ciešāka koordinācija starp medniekiem, PVD, VMD un citām iesaistītajām pusēm (IV). To apliecina, pētījumi Igaunijā (Urner et al., 2021).

Gan starptautiskajā zinatniskā literatūrā, gan Latvijas pieredzē uzsvērts, ka efektīvai ĀCM kontrolei nepieciešama integrēta pieeja, kas ietver mērķētu meža cūku populācijas pārvaldību, uzraudzības sistēmas pilnveidošanu un aktīvu ieinteresēto pušu iesaisti (Malmsten et al., 2017; Pepin et al., 2017; Bartoš et al., 2021). Arī veiktājā pētījumā iegūtie rezultāti apstiprina šādas pieejas nozīmi (IV). Pašlaik vienīgais tiesiskais instruments, kā regulēt meža cūku populāciju, ir medības. Medību process Latvijā tiek īstenotas stingri regulētā tiesiskā ietvarā, kur tiešo regulējumu nosaka Medību likums, kas definē medību jēdzienu un organizatoriskos principus (piem., 1. un 3. pants). Vienlaikus Dzīvnieku aizsardzības likums nosaka vispārējos dzīvnieku labturības principus, paredzot aizliegumu izturēties pret dzīvniekiem cietsirdīgi un pienākumu nodrošināt to nogalināšanu ar iespējami mazākām ciešanām (piem., 4. un 5. pants). Savukārt Civillikums reglamentē ar medībām saistītās īpašuma tiesības un atbildības aspektus, tostarp tiesības uz medījumu un zaudējumu atlīdzināšanas principus (piem., 927. pants un turpmākie panti). Attiecīgi populācijas skaita regulēšanu likumīgi var veikt tikai mednieki. Tomēr šī instrumenta efektivitāti ietekmē vairāki faktori, tostarp mednieku skaits, motivācija, ieinteresētība un attieksme pret dažādiem slimības apkarošanas pasākumiem (IV).

Līdzdalības pētījuma rezultāti parādīja, ka Latvijas mednieki kopumā ir motivēti atbalstīt ĀCM kontroli, taču vienlaikus sagaida, lai viņu centieni tiktu novērtēti un praktiski atbalstīti. Uzticēšanās valsts institūcijām, īpaši PVD un VMD, tika vērtēta kā salīdzinoši augsta, kas ir nozīmīgs priekšnoteikums slimības kontroles pasākumu īstenošanā (IV). Tomēr mednieki izteica skepsi par atsevišķiem kontroles pasākumiem, piemēram, žogu uzstādīšanu, intensīvu sivēnmāšu medīšanu un populācijas mazināšanu ar citu institūciju (piemēram armijas) iesaisti, un izrādīja lielāku atbalstu biodrošības pasākumu uzlabošanai un meža cūku vakcinācijai (IV), lai gan efektīva vakcīna pret ĀCM pašlaik vēl nav pieejama (EFSA, 2019).

Līdzīgi kā Calba et al. (2015) un Schulz et al. (2016), arī Latvijā veiktajā pētījumā lielākajai daļai mednieku bija grūti nosaukt pozitīvas sekas, kas rastos, atrodot meža cūkas līķi. Tomēr viņu motivāciju iesaistīties ĀCM ierobežošanā veicināja vēlme samazināt slimības ietekmi uz meža cūku populāciju (IV). Neraugoties uz to, ka līķu atrašana lielākoties tika uztverta kā negatīvs notikums, mednieki bija gatavi iesaistīties līķu meklēšanā un ziņošanā (IV). Turklāt mednieki demonstrēja izpratni par epidemioloģiskās situācijas dinamiku, norādot, ka nobeigušās meža cūkas atrašana var liecināt par iespējamu slimības atkārtotu parādīšanos konkrētajā teritorijā (IV).

Kā viens no efektīvākajiem instrumentiem mednieku motivēšanai piedalīties pasīvajā uzraudzībā tika minēta iespēja ziņot par meža cūku līķiem bez pienākuma pašiem veikt paraugu ņemšanu vai līķu iznīcināšanu. Šis priekšlikums tika papildināts ar ideju izstrādāt viedtālruņa lietotni ziņošanai un piesaistīt ārējus resursus meža cūku līķu meklēšanai (IV). Jāatzīmē, ka līdzīgs ziņošanas rīks Vācijā tiek izmantots jau kopš 2011. gada (Deutscher Jagdverband, n.d.), savukārt Latvijā VMD līdzīgu risinājumu ieviesa 2022. gadā.

Žogu uzstādīšana tika uzskatīta par finanšu resursu neefektīvu izmantošanu, jo to efektivitāte tika vērtēta skeptiski, turklāt tika uzsvērts, ka žogi rada šķēršļus arī citiem savvaļas dzīvniekiem (IV). Jāatzīmē, ka arī zinātniskajā literatūrā žogu efektivitāte un indes izmantošana ĀCM kontrolē tiek vērtēta pretrunīgi (Jori et al., 2020). Tikai divas grupas pieminēja indes izmantošanu kā iespējamu meža cūku populācijas kontroles pasākumu, un šo pieeju tās vērtēja ļoti negatīvi, kas liecina, ka šāds risinājums, visticamāk, nebūtu sabiedrībai pieņemams (IV).

Savukārt mednieku visbiežāk minētais potenciāli efektīvākais ĀCM apkarošanas risinājums bija vakcinācija (IV). Tomēr šāds kontroles rīks pašlaik vēl nav pieejams, jo efektīva un droša vakcīna pret ĀCM joprojām nav izstrādāta (EFSA, 2019). Vienlaikus uzskats, ka vakcinācija ir vienīgais efektīvais risinājums, var mazināt mednieku motivāciju īstenot pašlaik pieejamos kontroles pasākumus. Vakcīna ir rīks, kuru mednieki intuitīvi pieņem un kas potenciāli varētu risināt problēmu pašos tās pamatos. Kā efektīvu piemēru infekcijas slimības apkarošanai savvaļas dzīvnieku populācijā var minēt trakumsērgu, kur, pateicoties orālai vakcinācijai, slimības izplatība tika būtiski ierobežota, un, turpinot vakcināciju, trakumsērga savvaļas lapsu populācijā Rietumeiropā tika sekmīgi izskausta (Freuling et al., 2013).

Pētījumi par ĀCM vakcīnas izstrādi notiek jau vairākus gadu desmitus, un pēdējos gados šajā jomā ir panākts ievērojams progress. Kā viens no perspektīviem vakcīnas kandidātiem minams izolāts *Lv17/WB/Rie1*, kas iegūts no meža cūkas, kura tika nomedīta Latvijā 2017. gadā un tika izmantots vakcīnas izstrādē *HORIZON VACDIVA* projekta ietvaros (Gallardo et al., 2024). Tomēr vakcīnas izstrādi joprojām ierobežo vairāki faktori, tostarp vīrusa sarežģītā bioloģija, *DIVA* pieejas nodrošināšana, drošuma prasības, vakcīnas stabilitāte un efektivitāte savvaļas populācijā (Barasona et al., 2021; Gallardo et al., 2024).

Līdz drošas un efektīvas vakcīnas izstrādei galvenais ĀCM ierobežošanas instruments ir vīrusa cirkulācijas samazināšana vidē. To iespējams panākt, mērķtiecīgi meklējot un iznīcinot meža cūku līķus, kā arī kontrolējot meža cūku populācijas blīvumu līdz brīdim, kad ĀCM vīruss tiek pilnībā izskausts no meža cūku populācijas (I, II, III, IV).

Minetie aspekti uzsver nepieciešamību veidot slimības kontroles stratēģiju ciešā sadarbībā ar medniekiem, iesaistot viņus ĀCM apkarošanas pasākumu plānošanā un īstenošanā.

Mednieku praktiskās zināšanas par vietējām ekosistēmām un meža cūku populācijas dinamiku var būt nozīmīgs resurss slimības kontroles pasākumu efektivitātes uzlabošanā, īpaši, ja kontroles stratēģijas tiek saskaņotas ar vietējām medību tradīcijām un praksi (IV).

4.6. Virzība uz integrētu, bioloģiski pamatotu ĀCM pārvaldības stratēģiju

ĀCM epidemioloģiskās situācijas analīzes rezultāti Latvijā, liecina, ka atgriešanās pie ĀCM brīva statusa, visticamāk, nav sasniedzama, turpinot izmantot tikai līdz šim dominējošos apkarošanas pasākumus un pieejas. Promocijas darba ietvaros analizētie pētījumi norāda, ka slimības ilgstoša cirkulācija meža cūku populācijā ir cieši saistīta ar vīrusa saglabāšanos vidē, īpaši inficētos meža cūku līķos, kā arī ar populācijas ekoloģiskajām īpatnībām un cilvēka faktora ietekmi uz slimības uzraudzību un kontroli (I–IV).

Tādēļ ĀCM kontroles stratēģijas jāattīsta, virzoties uz integrētu un adaptīvu pieeju, kas balstīta uz meža cūku populācijas bioloģiju, slimības epidemioloģiju un praktisko pieredzi tās apkarošanā. Lēmumu pieņemšanai un kontroles pasākumu īstenošanai jābalstās uz aktuāliem epidemioloģiskajiem datiem, meža cūku subpopulāciju stāvokli, kā arī sezonālajiem faktoriem, kas ietekmē dzīvnieku uzvedību un vīrusa izplatības risku.

Kā viens no populācijas pieaugumu veicinošiem faktoriem literatūrā minēta meža cūku piebarošana (Guberti et al., 2022). Lai mazinātu šo ietekmi, piebarošana būtu stingri ierobežojama, tomēr kontrolētos apjomos tā var tikt izmantota pievilināšanas nolūkos medību efektivitātes uzlabošanai (Ozoliņš et al., 2025).

Pamatojoties uz promocijas darbā analizētajiem pētījumiem, nākotnes ĀCM pārvaldības stratēģijai būtu jābalstās uz vairākiem savstarpēji papildinošiem elementiem:

- Uzlabota pasīvā uzraudzība, kas balstīta uz sabiedrības efektīvu iesaisti un motivēšanas mehānismiem, nodrošinot savlaicīgu slimības gadījumu konstatēšanu (II; IV);
- Mērķtiecīga meža cūku līķu meklēšana un droša likvidēšana, kas samazina vīrusa saglabāšanos vidē un ierobežo infekcijas tālāku izplatību (I; III);
- Stratēģiska un nepārtraukta populācijas pārvaldība, kas vērsta uz populācijas blīvuma un struktūras kontroli, vienlaikus izvairoties no pasākumiem, kas var destabilizēt meža cūku sociālo struktūru (II; IV);
- Uzlabota komunikācija un sadarbība starp iesaistītajām pusēm, tostarp medniekiem, kompetentajām iestādēm un citām organizācijām (IV);
- Telpiskā riska kartēšana un epidemioloģiskā modelēšana, kas ļauj identificēt augsta riska teritorijas un pamatot slimības apkarošanas pasākumu plānošanu un optimizāciju (II).

Kopumā promocijas darbā iegūtie rezultāti liecina, ka ĀCM noturību meža cūku populācijā Latvijā galvenokārt nosaka vīrusa saglabāšanās vidē, īpaši meža cūku līķos, un populācijas ekoloģiskās īpatnības. Līdz ar to efektīva slimības kontrole ir iespējama tikai ar integrētu pārvaldības pieeju, kas apvieno mērķtiecīgu līķu meklēšanu un likvidēšanu, adaptīvu populācijas pārvaldību un aktīvu mednieku iesaisti uzraudzībā un kontroles pasākumu īstenošanā.

SECINĀJUMI

1. Kopš ĀCM apstiprināšanas Latvijā 2014. gada jūnijā vīruss ir kļuvis par dominējošo meža cūku populācijas dinamiku ietekmējošo faktoru. Vienlaikus meža cūku populācija funkcionē kā ĀCM vīrusa rezervuārs, nodrošinot tā persistenci, kura intensitāti nosaka telpiskie, laika un populācijas blīvuma faktori **(I, II, III).**

2. ĀCM uzraudzības sistēmā pasīvā uzraudzība ir jutīgāka un ir uzskatāma par epidemioloģiski efektīvāko instrumentu slimības agrīnai atklāšanai un vīrusa izplatības identificēšanai meža cūku populācijā. Savukārt aktīvā uzraudzība, kas balstās uz nomedīto dzīvnieku izmeklēšanu, galvenokārt raksturo infekcijas statusu meža cūku populācijā un slimības izplatības tendences, tomēr tās rezultāti ir ļoti atkarīgi no medību intensitātes, telpiskā pārklājuma un nomedīto dzīvnieku demogrāfiskās struktūras **(II, III).**

3. Latvijā īstenotie kontroles pasākumi, kas galvenokārt balstīti uz meža cūku populācijas samazināšanu ar (tradicionālo) medību palīdzību, līdz šim nav nodrošinājuši ĀCM vīrusa izskaušanu. **(II, III).**

4. Meža cūku līķi ir ĀCM vīrusa rezervuārs un infekcijas avots dabā, kas nodrošina ilgstošu vīrusa persistenci populācijā, tādēļ to savlaicīga atrašana un aizvākšana ir viens no būtiskākajiem slimības kontroles pasākumiem**.** Meža cūku bioloģiskās īpašības, tostarp augstā reproduktīvā kapacitāte, sociālā struktūra un ekoloģiskais plastiskums, ierobežo ĀCM apkarošanas pasākumu efektivitāti. Neselektīva medīšanas intensifikācija bez ilgtermiņa stratēģijas var izraisīt populācijas struktūras destabilizāciju, dzīvnieku pārvietošanās palielināšanos un strauju populācijas atjaunošanos, kam var sekot saslimšanas gadījumu skaita pieaugums **(II, III).**

5. Cilvēkfaktors, īpaši mednieku motivācija un izpratne, būtiski ietekmē tādu pasākumu efektivitāti, kā pasīvā uzraudzība un populācijas skaita (blīvuma) regulēšana. Ilgtspējīga un efektīva slimības ierobežošana iespējama tikai ar integrētu, uz pētījumiem balstītu stratēģiju, apvienojot epidemioloģiskos datus, bioloģiski pamatotu populācijas pārvaldību un ieinteresēto pušu sadarbību **(II, III, IV).**

6. Balstoties uz promocijas darbā iegūtajiem rezultātiem, izstrādātas rekomendācijas ĀCM kontrolei un apkarošanai meža cūku populācijā, integrējot epidemioloģiskos datus, meža cūku bioloģiju un ieinteresēto pušu iesaisti. Rekomendācijas ir iekļautas ĀCM uzraudzības un apkarošanas stratēģijā un rīcības plānā 2023.–2028. gadam, nodrošinot pētījuma rezultātu praktisku izmantošanu valsts līmenī (**I, II, III, IV**).

REKOMENDĀCIJAS ĀCM KONTROLEI MEŽA CŪKU POPULĀCIJĀ

Balstoties uz šī pētījuma rezultātiem, ĀCM efektīvai kontrolei meža cūku populācijā Latvijā nepieciešama integrēta, epidemioloģiski pamatota un adaptīva pieeja, balstoties uz šādiem pasākumiem:

1. Pasīvās uzraudzības (atrasto beigto meža cūku līķu laboratoriskā diagnostika) stiprināšana.

Pasīvā uzraudzība ir jutīgākais un epidemioloģiski efektīvākais ĀCM agrīnās atklāšanas instruments (II, III).

Nepieciešams:

- prioritizēt meža cūku līķu aktīvu meklēšanu kā galveno uzraudzības komponenti;
- vienkāršot un digitalizēt ziņošanas sistēmu, turpinot attīstīt un pilnveidot digitālos rīkus (piem., mobilo lietotni "Mednis");
- nodrošināt vienkāršu un operatīvu paraugu noņemšanas mehānismu;
- attīstīt datu apmaiņu starp iesaistītajām institūcijām.

2. Meža cūku līķu savākšana un iznīcināšana.

Meža cūku līķi ir nozīmīgākais ĀCM vīrusa persistences faktors populācijā un infekcijas avots dabā (III).

Tādēļ būtu:

- jānodrošina sistemātiska un koordinēta līķu meklēšana augsta riska teritorijās;
- jāizstrādā operatīvs līķu savākšanas un iznīcināšanas mehānisms;
- jāprioritizē resursu novirzīšana līķu savākšanai un iznīcināšanai kā vienam no efektīvākajiem kontroles pasākumiem;
- jāiesaista apmācīti mednieki un pašvaldības dienesti, ievērojot atbilstošus biodrošības pasākumus.

3. Aktīvā uzraudzība (nomedīto meža cūku izmeklēšana).

Aktīvā uzraudzība būtu jāīsteno kā papildinošs, mērķēts instruments, nevis primārais ĀCM uzraudzības veids (II, III).

Tādēļ:

- tā būtu jāveic mērķtiecīgi definētās riska teritorijās, ko nosaka balstoties uz epidemioloģiskajiem datiem;
- jānosaka skaidrs un ierobežots īstenošanas periods, lai nodrošinātu operatīvu situācijas izvērtējumu;

- tās galvenais mērķis ir novērst potenciāli inficētu meža cūku nonākšanu pārtikas apritē, vienlaikus iegūstot datus par ĀCM epidemioloģisko stāvokli populācijā.

4. Mērķtiecīga meža cūku populācijas pārvaldība.

Populācijas regulācija būtu jābalsta uz epidemioloģiskajiem datiem un sugas bioloģiju. Ieteicams:

- īstenot mērķtiecīgas selektīvas medības, samazinot reproduktīvo mātīšu īpatsvaru;
- izvairīties no fragmentētām un neregulārām medībām, kas var veicināt populācijas destabilizāciju;
- pieļaut piebarošanu tikai kā pievilināšanas instrumentu medību efektivitātes uzlabošanai, ievērojot biodrošības principus;
- ieviest un attīstīt meža cūku dzīvķeršanu kā papildu efektīvu populācijas regulācijas instrumentu;
- veicināt medījumu (t.sk. meža cūku) gaļas plašāku nonākšanu pārtikas apritē, tādejādi veicinot medīšanu un palielinot nomedīto meža cūku skaitu.
- pielāgot medību intensitāti un struktūru konkrētajai teritorijai (medību iecirknim) un epidemioloģiskajai situācijai.

5. Mednieku iesaiste un cilvēkfaktors.

Mednieku līdzdalība ir kritisks faktors pasīvās uzraudzības un efektīvai meža cūku populācijas kontroles nodrošināšanai.

Nepieciešams:

- stiprināt sadarbību starp medniekiem un valsts institūcijām.
- apmācīt un informēt medniekus par ĀCM īpašībām un aktuālo epidemioloģisko situāciju, apkarošanas pasākumu nozīmi un rezultātiem;

Pilnveidot motivācijas mehānismus (finansiālus, organizatoriskus un praktiskus), lai veicinātu mednieku un sabiedrības aktīvāku iesaisti ĀCM uzraudzības un kontroles pasākumu īstenošanā;

6. Integrēta un adaptīva pārvaldības pieeja.

ĀCM kontrole būtu jāīsteno kā dinamiska, uz zinātnisko pētījumu rezultātiem balstīta sistēma.

Ieteicams:

- regulāri analizēt ĀCM uzraudzības datus (PCR, seroprevalence, izplatība laikā un telpā);
- piemērot zonētu pieeju ar atšķirīgām stratēģijām teritorijās ar dažādu epidemioloģisko situāciju;

- definēt reāli sasniedzamus meža cūku populācijas blīvuma mērķus un regulēšanas mehānismus, par prioritāti izvirzot ĀCMV cirkulācijas samazināšanu un epidemioloģiskā riska mazināšanu;
- stiprināt starpinstitucionālo sadarbību;
- turpināt zinātniskos pētījumus par meža cūku populācijas dinamiku, ĀCM vīrusa persistenci un apkarošanas pasākumu efektivitāti, lai nodrošinātu savlaicīgu un pierādījumos balstītu pārvaldības lēmumu pieņemšanu.

PATEICĪBAS

Mana promocijas darba tapšana nebūtu iespējama bez daudzu cilvēku atbalsta, zināšanām un iedrošinājuma. Vēlos izteikt sirsnīgu pateicību visiem, kuri dažādos veidos ir bijuši līdzās šajā profesionāli un personīgi nozīmīgajā ceļā.

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Esmu pateicīgs arī par Latvijas Zinātņu akadēmijas piešķirto augsto novērtējumu – diplomu par vienu no nozīmīgākajiem 2025. gada sasniegumiem Latvijas lietišķajā zinātnē par pētījumiem ĀCMV epidemioloģijas, uzraudzības un kontroles stratēģiju jomā. Šis novērtējums kalpoja kā nozīmīgs apliecinājums pētījuma aktualitātei un motivācija turpināt iesākto darbu.

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African swine fever virus introduction into the EU in 2014: Experience of Latvia

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ABSTRACT

African swine fever (ASF) virus was introduced in Latvia in June 2014. Thirty-two outbreaks in domestic pigs and 217 cases in wild boar were notified in 2014. Twenty-eight outbreaks (87.5%) were primary outbreaks. The contagiosity within pig herds was low. Failure to use simple biosecurity measures to reduce the chance of virus introduction, for example by inadvertent feeding of locally produced virus contaminated fodder were the main causes for the outbreaks in backyard holdings. The infection in wild boar survived locally in two different areas with a low prevalence and a slow spread. The persistence of the infection in wild boar within an area was most probably linked to wild boar scavenging the carcasses of infected wild boar.

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The African swine fever virus (ASFV) currently affecting Eastern European countries and Baltic States has been classified as genotype II and is highly virulent, leading to high rates of lethality in infected animals and associated with peracute and acute haemorrhagic disease (Blome et al., 2012; Gallardo et al., 2015). The epidemic started in Georgia in 2007 and spread throughout the Caucasus and the Russian Federation where the disease has become endemic (Gogin et al., 2013; Sánchez-Vizcaíno et al., 2013). In July 2012, ASF was detected in Ukraine and in June 2013 it was notified by Belarus (EFSA, 2014). In January 2014 ASFV was confirmed in wild boar in Lithuania and in February 2014 in Poland.

ASF was detected in Latvia in June 2014, with a total of 32 outbreaks in domestic pigs and 217 wild boar cases reported by year end. For disease confirmation blood and tissue samples were tested for the presence of virus genome and antibodies at the Latvian National Reference Laboratory for ASF. For ASFV detection real-time PCR was used according to the ASF diagnostic manual of the EU (Anonymous, 2003). For antibody detection a commercially available ASF antibody ELISA (INGEZIM PPA COMPAC ELISA, Ingenasa) was used according to the manufacturer's instructions. ELISA positive and doubtful results were confirmed by Immunoperoxidase technique.

Twenty outbreaks occurred in backyard holdings with up to ten pigs; ten holdings had between 11 and 50 pigs; one holding had 56 pigs and one holding had 196 pigs. Most of the outbreaks (n = 30) occurred during July and August 2014. Twenty-five outbreaks were located in the south-eastern part and seven outbreaks in the north of Latvia. All outbreaks were detected in areas where ASF was present in wild boar.

On the 32 infected pig holdings a total of 585 animals were present of which 147 were sampled. Sixty-nine animals were found to be PCR positive. A total of seven pigs were both sero-positive and PCR positive; these pigs were located at three different holdings.

Thirty-one of the infected farms have been identified by passive surveillance. One farm has been detected by active surveillance. It can be concluded that passive surveillance worked properly confirming the success of awareness campaigns carried out by the Food and Veterinary Service.

Twelve farms were notified as suspected before any animal died whereas on 20 farms veterinarians were called after the death of at least 1 pig. On several holdings only one or a few diseased or dead animals were present at the time of suspicion. Other animals, living in the same stable, were clinically healthy. It appears that, at least at the

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Table 1
Laboratory results for ASF of hunted and found dead wild boar (WB) in the infected regions of Latvia in 2014[a].

Regions	Area size (infected counties)	Estimated WB density	Hunted WB	WB found dead	Cases
	km^2	(animals/km^2)	(PCR+) Prevalence	(PCR+) Prevalence	
Latgale-North	4166	2000 (0,5)	973 (2) 0,2%	10 (7) 70%	9
Latgale-South	2974	1800 (0,6)	838 (24) 2,9%	89 (60) 67,4%	84
Madona	2962	2000 (0,7)	290 (0)	24 (13) 54%	13
Vidzeme	2807	2000 (0,7)	666 (15) 2,3%	122 (95) 88%	110
Total	12,909	7800 (0,6)	2765 (41) 1,5%	245 (175) 71,4%	216

[a] One ASF case from the Alūksne region which is linked epidemiologically and geographically with cases in south Estonia is not included in this table.

onset, ASFV had a very low transmission rate and a clear evidence of pig-to-pig transmission during the early stage of infection was lacking. These field observations indicate that virus transmission from one animal to the next is rather a delayed process confirming a moderate ASF contagiosity. Similar observations have been made under experimental conditions with the same genotype II virus (Pietschmann et al., 2015).

Twenty-eight outbreaks (87.5%) were classified as primary outbreaks and four outbreaks (12.5%) were seen as secondary outbreaks; 16 primary outbreaks were most probably caused by swill feeding while 12 outbreaks could be linked to the ongoing infection in the wild boar population. The secondary outbreaks were caused by people having contacts with infected farms.

All outbreaks were detected within four weeks from the time of virus introduction in the farm. Indicators like a number of sick or dead animals and the presence of PCR positive and/or seropositive animals at the time of suspicion were used to estimate more exactly the potential date of virus introduction. In the absence of any seropositive but only PCR positive animals (n = 29), infection was not older than two weeks. On three farms where PCR positive and seropositive animals were found, infection must have lasted for about 2–4 weeks. Farms with convalescent animals which would have tested seropositive only, indicating an older introduction, were not found.

Biosecurity shortcomings and feeding of potentially contaminated fresh grass or crops were the most serious factors responsible for virus introduction into the holdings. However swill feeding as a source could not be excluded. Basic biosecurity measures, change of footwear, outer clothing and disinfecting as required by national legislation were not followed.

Regarding the disease in wild boar 175 (71.4%) of the positive cases belonged to the group of animals (n = 245) which were found dead in the forests and fields (Table 1). From the 2765 hunted wild boar 41 (1.7%) tested PCR positive. In total 24 (0.9%) out of 2475 tested animals had ASF antibodies; 14 of the seropositive wild boar were also PCR positive while 13 animals had antibodies only.

The first positive wild boar (n = 7) were found in the Dagdas County (Latgale-South Region), located on the border with Belarus (Fig. 1). It was assumed that the virus entered Latvia via infected wild boar at the beginning of June 2014.

A further 77 wild boar cases were detected by December 2014 in Latgale-South Region. In Latgale-North positive animals (n = 9) were detected only from August until October. A direct link between the two different clusters (Latgale-South and Latgale-North) could not be demonstrated.

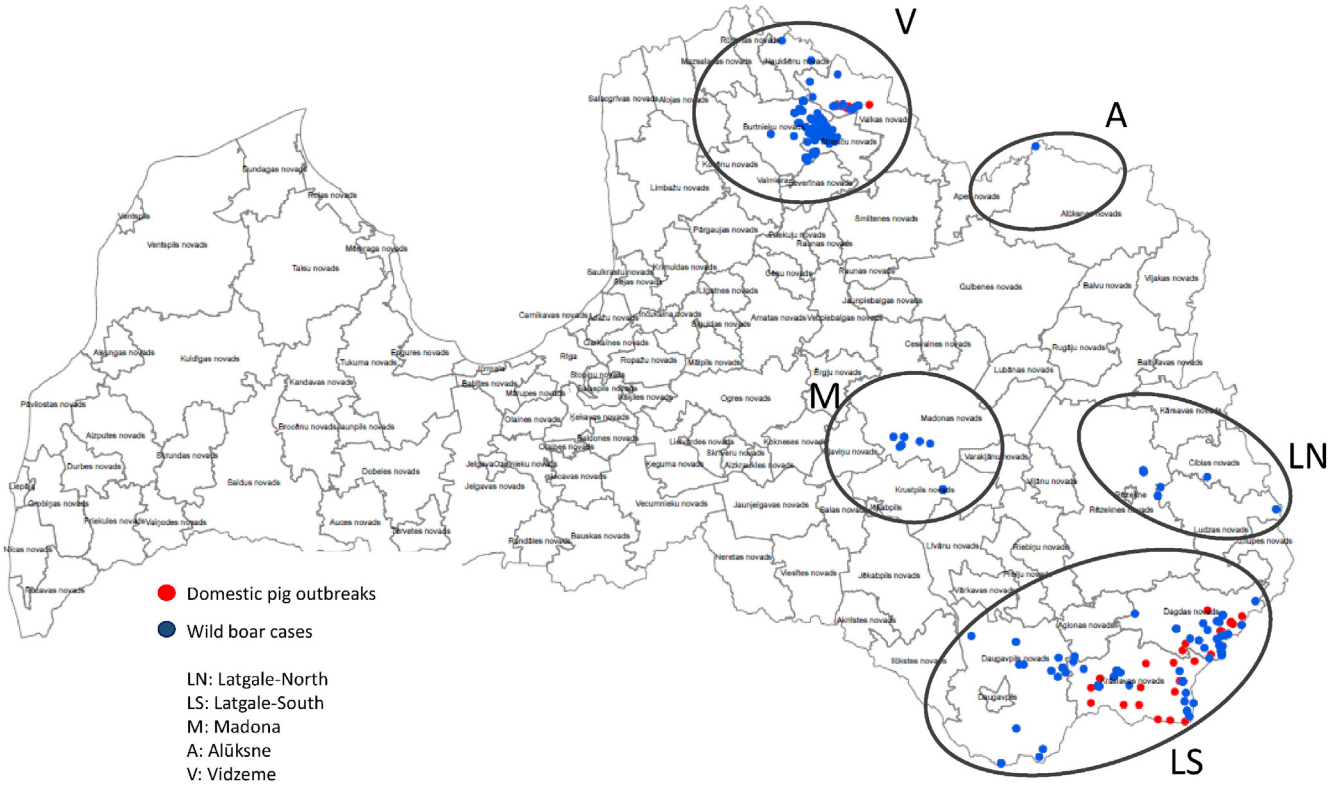

Fig. 1. Location of ASF outbreaks and cases in Latvia in 2014.

The second region affected by ASF was Vidzeme in the north of Latvia (July, 2014), a region that shares a border with Estonia. Illegal disposal of offal into the forest from slaughtered pigs and wild boar with unknown status might have initiated the infection. In September 2014 the first positive cases were reported from Estonia on the other side of the border. It was concluded that infection spread from Vidzeme region in Latvia to south of Estonia.

The third region affected by ASF was Madona. The virus introduction must have occurred mid/end July when an increased virus activity was observed in the Latgale region. However, it remained unclear how ASFV reached Madona.

In Latgale-South and Vidzeme the infection kept ongoing locally with a steady low prevalence (below 3%) and without any rapid spatial spread.

The persistence of the infection in wild boar population within an area was most probably linked to the long term survival of the virus in the environment including carcasses which may remain in the fields for weeks.

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OPEN

Epidemiological evaluation of Latvian control measures for African swine fever in wild boar on the basis of surveillance data

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A wild boar population infected with African Swine Fever (ASF) constitutes a constant threat to commercial pig farms and therefore to the economy of the affected country. Currently, ASF is still spreading in several countries and the implementation of intensive measures such as reducing wild boar population densities seems not to be able to stop the further spread of the disease. In addition, there are still substantial knowledge gaps regarding the epidemiology of the disease. To identify risk factors for a higher probability of a wild boar sample being virological or serological positive, comprehensive statistical analyses were performed based on Latvian surveillance data. Using a multivariable Bayesian regression model, the effects of implemented control measures on the proportion of hunted or found dead wild boar or on the estimated virus prevalence were evaluated. None of the control measures applied in Latvia showed a significant effect on the relevant target figure. Also, the estimated periodic prevalence of wild boar that had tested ASF positive by PCR appeared to remain unaffected over time. Therefore, there is an urgent need to reconsider the implemented control measures. The results of this study and the course of ASF in other affected countries, raise the question, whether an endemic situation of ASF in wild boar is reversible.

Due to its high case-fatality ratio, African Swine Fever (ASF) is one of the most dreaded viral diseases in swine, especially in countries with a considerable pig industry[1]. As yet, there is no effective treatment or vaccination available[2,3].

ASF was introduced into South-Eastern Europe through Georgia. Shortly afterwards, the virus was detected in several other countries in the region[4–7]. It took seven years, until the epidemic had reached countries in the East of the European Union. Initially, Lithuania and Poland were affected, followed by Latvia and Estonia[6,8]. However, in the course of time, the disease also reached the Czech Republic, Romania, Hungary, Belgium and Bulgaria. As additional non EU countries, Moldova and since August 2018 also China are affected (OIE WAHID interface, visited online 13 August 2018). ASF has first been detected in the Latvian wild boar population in June 2014 and has been present there since then.

Outbreaks of ASF in domestic pigs occurred in several countries, but were usually controlled using conventional measures of animal disease control such as culling of affected pig holdings, safe disposal of the carcasses, cleaning and disinfection, movement restrictions, monitoring and surveillance. In regions, however, where ASF had the chance to spread in the wild boar population, controlling the disease in wild boar, not to mention eradicating it, was largely unsuccessful[4,9,10]. This is of particular importance as wild boar have been shown to play a significant role in disease transmission and maintenance[7,11]. Several strategies have been proposed to control ASF in wild boar population, including the ban of large-scale drive hunts, the implementation of massive targeted hunting and the removal and safe disposal of wild boar carcasses from the environment[12,13]. The effect of these measures is controversially discussed and many are assumed to have a low efficacy, e.g. use or ban of supplementary

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Measure	Control measure	Time period of measure implementation
A	Incentives to all persons who report dead wild boar to the veterinary authorities	July 2014–March 2015
B	Incentives to hunters (200 Euros per hunted wild boar older than 1 year, 50 Euros for wild boar of less than 1 year)	July 2014–Sept 2014
C	Collection and safe disposal of dead wild boar carcasses (done by the Food and Veterinary Service)	26 June 2014–March 2015
D	Notification, collection and safe disposal of dead wild boar carcasses (done by hunters)	April 2015–Jan2016
E	Collection and safe disposal of dead wild boar carcasses (Responsibility of local municipalities - mostly done by hunters)	Feb 2016–Dec 2017
F	Winter feeding ban	since 10 Dec 2014
G	Baiting of wild boar only allowed for hunting purposes	since 10 Dec 2014
H	Restrictions on driven hunts	Oct 2014–Feb 2015
		Oct 2015–Feb 2016
I	Incentives for hunting adult and sub-adult female wild boar	Nov 2015–March 2016
		Oct 2016–Dec 2017
J	Permission to use sound moderators (silencers) and night vision devices for wild boar hunting	since April 2015

Table 1. Measures implemented to control African swine fever in wild boar in Latvia.

feeding of wild boar[8,14]. However, the restricting or prohibiting of drive hunts and paying incentives for carcass removal are considered to be reasonably effective[8,12].

Nurmoja, *et al.*[9] showed a positive association between wild boar population density and an increased incidence of ASF cases in wild boar. Accordingly, it is generally accepted that a drastic reduction of the wild boar population, at least in the surroundings of foci with the occurrence of ASF in wild boar may help to control ASF in this species[8,15]. Although this approach appears promising in the model, its practicability is doubtful. Lange[15] showed by mathematical modelling that conventional strategies of wild boar population management (e.g. targeted hunting) must be conducted over several years to lead to a clear decrease of the wild boar population size. Furthermore, a recent study suggests that the role of the population density in the spread of ASF within wild boar might be less important than previously assumed[16].

In Latvia, various control measures were implemented for different periods of time during the current epidemic (Table 1).

However, the continuous spread of ASF in the wild boar population in Latvia suggests that these measures were not sufficient to contain the epidemic.

Following these observations, the present study aimed to evaluate the effects of the Latvian control measures on the respective target figures on the basis of available surveillance data, i.e. the effect on the proportion of samples originating from animals hunted or found dead or on the estimated ASFV genome prevalence.

Due to the existing knowledge gaps regarding the epidemiology of ASF, risk factors for a higher probability to detect ASF positive samples were additionally identified.

The results of the study may be used to improve assessments of the success of control measures for ASF in wild boar. They also allow adjusting the applied measures as appropriate.

Material and Methods

Study area. The study area consisted of three different regions in Latvia, from where a sufficiently large sample size was available, i.e. Latgale region, which is bordering Belarus, Vidzeme region, bordering Estonia, and Madona County, which is located between the two regions (Fig. 1). In total, the study area included 20 counties and comprised of approximately 15,146 km^2. The towns of Daugavpils and Valmiera were excluded from the analyses.

Data. Surveillance data were extracted from the CSF/ASF wild boar surveillance database of the European Union (https://surv-wildboar.eu). The study period ranged from 25.06.2014 (first detection of ASF in wild boar in Latvia) to 31.10.2017 (41 months). There was one individual data set for each wild boar, which contained information about date and location where the sampled animal had been hunted or found dead, the estimated age of the animal and the laboratory test result of the sample (detection of virus genome by PCR and serology). Regarding age, animals were categorized in two classes, younger than one year and one year or older. Furthermore, information was recorded for the origin of each sample (in the following text termed carcass type), i. e. shot apparently healthy (active surveillance) or shot sick, found dead or involved in a road traffic accident (passive surveillance). Data with an inconclusive result in any of the variables were excluded.

Laboratory testing of samples for ASFV genome and ASF-specific antibodies was performed in the Latvian Institute of Food Safety, Animal Health and Environment (BIOR) by the Animal Disease Diagnostic Laboratory. For antibody detection and ASFV genome, blood samples were taken by the hunters from hunted wild boar. Organ (kidney, spleen, lymph node) or bone marrow samples were collected from animals found dead and analyzed for virus genome.

In 2014 and 2015, detection of ASFV genome was performed by real time PCR[17], but from 2016 onwards, the UPL protocol established by Reference Laboratory for ASF of the European Union[18] was used. Antibody testing was done by using a commercial blocking enzyme-linked immunosorbent assay (ELISA) (INGENASA,

Figure 1. The study area comprised of three regions, i.e. Latgale region in the South, Vidzeme region in the North and Madona County in between. Map was generated by using ArcGIS ArcMap 10.3.1 (ESRI, Redlands, CA, USA).

INGEZIM PPA COMPAC, Spain) and positive results confirmed with the indirect immunoperoxidase test (IPT), validated by the Reference Laboratory for ASF of the European Union.

The State Forest Service provided wild boar population data that were used to assess the wild boar population density. Data were available on game management unit for the hunting seasons (April of a year until March of the following year) during the ASF epidemic (2014/15, 2015/16, 2016/17). The definition of the game management units is based on habitat and human related landscape characteristics (e.g. human population density, land use, major roads and rivers). They are used to manage all species of game. The number of wild boar in each game management unit was estimated on the basis of the hunting bag, population structure data (number of hunted animals divided by their age and gender), current occurrence evidences (e.g. visual observations, foot prints etc. observed by hunters or forest rangers) and information on wild boar damage to crop production claimed by local farmers. Estimations were annually done with a deadline on the 1st of April of each year for the previous year, for each game management unit by a local official of the State Forest Service, who collected and amalgamated the information.

For analysis, the data was aggregated at municipality level. The software ArcGIS ArcMap 10.3.1 (ESRI, Redlands, CA, USA (http://www.esri.com/) was used to calculate the wild boar density per km² based on the estimated number of wild boar per game management unit. Areas of game management units that overlapped with the territories of at least two municipalities were proportionally attributed to the territory of each municipality. On the basis of the wild boar density per km² and the adapted game management units, the total number of wild boar per municipality was calculated. The average values of the wild boar densities of the three hunting seasons were determined and assigned to each corresponding municipality. An additional dataset on wild boar population density was available from the time before ASF had emerged in Latvia (hunting season 2011/12). In contrast to the hunting data of the years during the ASF epidemic, these data were only available on regional subunits of the State forest service (geographically larger than municipalities). These data were assigned to the administrative district level. To ensure comparability, the data of the hunting seasons during the ASF epidemic had to be adapted accordingly. To this end, the centroid of the municipalities was used to assign the wild boar densities of the municipalities to the respective administrative district. The number of wild boar in the individual municipalities, which belonged to one particular administrative level, were summarized and the wild boar densities for each administrative district calculated.

Maps and figures. Maps were generated using ArcGIS ArcMap 10.3.1 (ESRI, Redlands, CA, USA, http://www.esri.com/). Figures were generated using the software package R (http://www.r-project.org)[19].

Statistical analyses. Statistical analyses were performed using the software package R (http://www.r-project.org) if not stated otherwise. Confidence intervals were calculated according to Clopper and Pearson[20]. A p-value of ≤ 0.05 was considered statistically significant.

The statistical analyses of population data and the association between potential risk factors for a higher probability to detect ASF-positive samples and the ASF laboratory test result were performed essentially as described by Nurmoja, *et al.*[9]. Correspondingly, potential associations between age and test result as well as carcass type and test result were examined using Fisher's exact test. Potential associations between carcass type and age were analyzed in the same manner. The estimated periodic prevalence of ASFV genome-positive wild boar and the seroprevalence of ASF-specific antibodies with the respective 95% confidence intervals were calculated and the temporal course of the prevalence data was analyzed.

Potential differences in population densities between different hunting seasons were investigated using a non-parametric Kruskal-Wallis test. If a statistically significant difference was detected, pairwise Mann–Whitney U tests were performed. To control the type I error for multiple testing, the Bonferroni correction[21] was applied in these comparisons.

To study the effect of control measures on the wild boar population, or the estimated periodic ASFV genome prevalence, an appropriate control period was defined for each period, during which the specific measure was in place (Table 2, Figs 2 and 3). When determining the control period, we aimed to choose the same number of month and the same season as in the period, during which the measure was applied. Ideally, no other measure with a potential impact on related parameters (e.g. increase of hunted wild boar/increase of animals found dead) was in place during the control period. Accordingly, for some measures the control periods had to be chosen before, and for others after the periods, when the measures were applied.

For some measures, no control period could be established. These measures were excluded from the analysis (measures F and G in Table 1). Moreover, only measures with a direct effect on the composition of the population, the carcass type (animals hunted or found dead) or the estimated ASFV genome prevalence were considered. Accordingly, measures C, D and E (Table 1) were excluded from further analysis.

To test the Null hypotheses and thus the effect of the measure on the estimated ASFV genome prevalence or the proportion of hunted/found dead wild boar a multivariable Bayesian regression model was used[9,22]. A proportion of mean/Std.Dev. >1.96 was regarded as statistically significant.

Each measure was defined as the independent variable. In each model, age was included as fixed effect. Accounting for the epidemiological situation over time, in the case of carcass type (proportion of hunted/found dead wild boar) as dependent variable, the estimated ASFV genome prevalence in each month of the respective measure/control period was included as fixed effect. The origin of sample (hunted/found dead) was included as fixed effect in the models where the estimated ASFV genome prevalence constituted the dependent variable. Time (in months) was treated as a random effect. To estimate the parameter values, a Markov Chain Monte Carlo algorithm (MCMC) was used. 50,000 iterations were performed and at every 50th iteration a sample was selected. For the burn-in 1,000 iterations were chosen. The model was implemented using BayesX 2.0.1 (http://www.uni-goettingen.de/de/bayesx/550513.html) and convergence of the MCMC chain was assessed using standard diagnostic plots and tests. A detailed model description can be found in the supplementary information.

Stepwise model building using forward selection were used to find the best model for each measure. The models were evaluated on the basis of their Deviance Information Criterion (DIC) and the Effective number of parameters (pD). For each measure the model with the smallest DIC were used for the final analyses. In the case of comparable DICs, the model with the smallest pD was chosen (Supplementary information Tables S2, S8).

Results

Data. In total, 12,978 data records were available for analysis. Of these, 5,224 records originated from Latgale region, 5,379 from Vidzeme region and 2,375 from Madona County.

Statistical analysis. A significant association between age and positive laboratory test results (both, ASFV genome and serology) was found. When analyzing all samples, the probability to find a positive test result was higher in young animals (Table 3). The probability that a sample originating from an animal found dead came from a younger animal was significantly higher as compared to older wild boar. The probability to detect a positive test results in wild boar found dead was significantly higher than in hunted animals (Table 3).

Temporal changes in population density were also detected: Compared to the hunting season of 2011/12, the wild boar density decreased significantly starting with 2014 until the hunting season of 2016/17 ($p < 0.001$) (Fig. 4).

The estimated ASF prevalence, regardless of the laboratory testing method, i.e. ASFV genome detection or serology, hardly showed any statistically significant changes during the study period of 41 months (Fig. 5).

For the model analyses, models with the lowest DIC were used (Table 4, Supplementary information Tables S2, S8). None of the measures resulted in a significant effect on the variable of interest (carcass type or estimated ASFV genome prevalence).

Paying incentives to all persons who reported dead wild boar to the veterinary authorities (control measure M1, Table 2) yielded a greater effect on the estimated ASFV genome prevalence (1.20) than most of the other measures. However, the difference between the estimated prevalences in the two time periods was nearly zero (Supplementary information Table S1). Also, permission to use silencers and night vision devices for wild boar hunting (control measure M5) seemed to have a stronger effect, albeit not significant, on the proportion of hunted wild boar and on the estimated ASFV genome prevalence (Table 4). In addition, the number of hunted wild boar was larger in the period when control measure M5 had been implemented (Supplementary information Table S1).

Paying incentives to hunters for hunted wild boar (control measure M2) had no statistically significant effect on the proportion of hunted animals (Table 4) but also a lower number of hunted animals in the time when the measure was applied as compared to the time, when it was not applied (Supplementary information Table S1).

	Measure	Measure/Control period Null hypothesis
M1	Incentives to all persons who report dead wild boar to the veterinary authorities (corresponds to A in Table 1)	Measure period (M1 = C5): July 2014 – March 2015 Control period (C1 = M5): July 2015 – March 2016
		$H_0$1: No significant effect of M1on the **proportion of animals found dead** $H_0$2: No significant effect of M1on the **estimated ASFV genome prevalence**
M2	Incentives to hunters for hunted wild boar (corresponds to B in Table 1)	M2: July 2014 – Sept 2014 C2: July 2015 – Sept 2015
		H_0: No significant effect of M2 on **the proportion of hunted animals**
M3	Restrictions on driven hunts (corresponds to H in Table 1)	M3a: October 2014 – February 2015 M3b: October 2015 – February 2016 C3a + b: October 2016 – February 2017
		H_0: No significant effect of M3 on the **estimated ASFV genome prevalence**
M4	Incentives for hunting adult and sub-adult female wild boar (corresponds to I in Table 1)	M4a: November 2015 – March 2016 M4b: October 2016 – October 2017 C4a: November 2014 – March 2015 C4b: October 2014 – October 2015
		H_0: No significant effect of M4 on **the proportion of hunted animals**
M5	Permission to use sound moderators (silencers) and night vision devices for wild boar hunting (corresponds to J in Table 1)	M5 = C1: July 2015 – March 2016 C5 = M1: July 2014 – March 2015
		$H_0$1: No significant effect of M5 on **the proportion of hunted animals** $H_0$2: No significant effect of M5 on the **estimated ASFV genome**

Table 2. Control measures for African swine fever in wild boar in Latvia analyzed for their effect on the estimated ASFV genome prevalence, the proportion of hunted animals or found dead.

The estimated ASFV genome prevalence was higher in the period when driven hunts were restricted (control measures M3a and M3b) as compared to the time, when there were no limitations of driven hunts (Supplementary information Table S1). These finding was also supported by the model analyses. However, the effect of the measure on the estimated ASFV genome prevalence was not significant (Table 4). Paying incentives for hunting adult and sub-adult female wild boar (control measure M4a and M4b) also failed to show a statistically significant effect on the proportion of hunted wild boar in any of the periods, during which this control measure was applied (Table 4).

Discussion

The aim of the study was to evaluate the effect of measures that had been applied in Latvia to control ASF in wild boar. In view of the fact that there are still substantial gaps in our knowledge about the epidemiology of ASF, particularly in wild boar[23,24], we also tried to address some of these gaps. Therefore, risk factors for a higher probability to detect ASF-positive wild boar were investigated.

In close cooperation with the Latvian veterinary authorities, three regions were determined as the study area. From these regions, which were typical for other parts of the country, also with regard to the occurrence of ASF in wild boar, a wide range of surveillance and wild boar population data originating from different epidemiological situations were available.

According to EU legislation (Council Directive 2002/60/EC), it is mandatory to sample all hunted and dead wild boar in ASF-affected areas. It can thus be assumed that the obtained sample size in areas affected by ASF corresponds to the entire hunting bag, i.e. usually at least 60–80% of the population. However, due to hunting habits such as the desire for trophies, some older and very young wild boar are usually not shot. Therefore, the composition of the hunting bag does not completely mirror the structure of the wild boar population[25–28]. Nonetheless, the sample size available from ASF- affected areas is still large as compared to other wildlife studies[29–32]. Consequently, although respecting the uncertainty regarding the true population size and the true epidemiological situation of ASF in Latvian wild boar, we assumed that the sample size was sufficient for our analyses to estimate the periodic ASFV genome prevalences and seroprevalences with a high confidence.

The results regarding the association of risk factors and laboratory test results were in line with results obtained in a study recently conducted in Estonia[9]. The majority of samples resulted from adult wild boar and was obtained by active surveillance. However, the probability to find an ASF-positive animal was significantly higher in wild boar found dead, i.e. passive surveillance. This result is in accord with previous findings and emphasizes the urgent need to enhance the number of samples resulting from passive surveillance[7,9,33–35]. The fact that similar results were obtained in several countries affected by ASF in wild boar suggests that the risk factors for a higher probability to detect an ASF-positive sample are also similar, regardless of the environment, the region or the population density. Therefore, one can assume that the course of ASF within wild boar populations is comparable between affected countries or regions. The increased probability that a wild boar that was found dead was younger than one year suggests that young animals are at a higher risk to die. The cause of death may be ASF in the study area, but other reasons such as infections with agents other than ASFV or predation cannot be excluded[28,36].

Although estimated population densities in different hunting seasons may not be independent, due to the lack of a suitable alternative, independence was assumed and the conservative non-parametric Kruskal-Wallis test used for statistical comparison.

Over the years, a significant reduction of the estimated wild boar population density was observed. This is probably due to the continuous spread of ASF and its high case-fatality ratio. To rule out completely that the

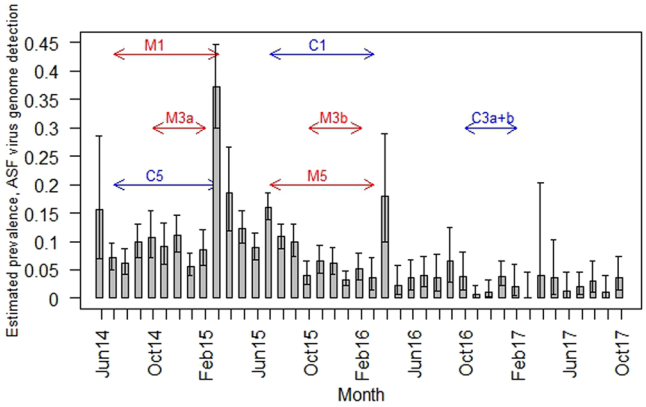

Figure 2. Estimated prevalence of African Swine Fever virus genome-positive wild boar (boxes) and 95% confidence intervals (whiskers) for each month of the study period. Red arrows illustrate the time span for the different measures, which aimed to influence the prevalence. Blue arrows illustrate the corresponding control periods. The numbering of measures and controls follows Table 2. Figure was generated by using the software package R (http://www.r-project.org).

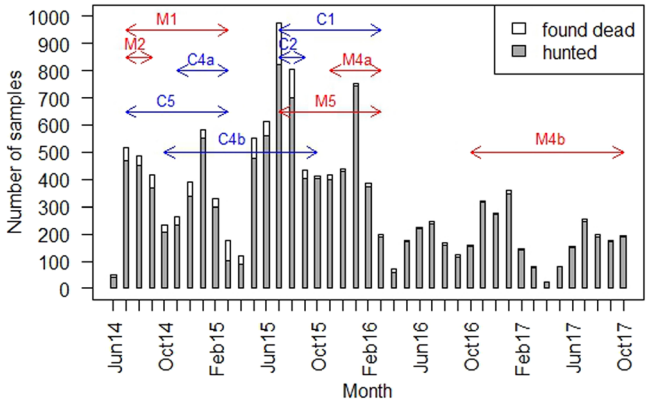

Figure 3. Number of samples originating from hunted wild boar or wild boar found dead. Red arrows illustrate the periods, when various measures that aimed at influencing the proportion of hunted/found dead wild boar were applied. Blue arrows illustrate the corresponding control periods. The numbering of measures and controls was performed according to Table 2. Figure was generated by using the software package R (http://www.r-project.org).

decrease was not just an effect of intensified hunting in these areas, further data, from the western part of Latvia should be analyzed and compared. In these regions, ASF cases occurred after 2015 but hunting strategies were the same as in affected regions. However, such analyses were beyond the scope of the present study as only data of the defined study area were used. Moreover, only data of one hunting season (2011/12) before the emergence of ASF were available. Therefore, it remains unknown, if the population density in the hunting years 2012/13 and 2013/14 was higher than in the years after ASF had been introduced into the wild boar population. Furthermore, when interpreting the temporal trend of the wild boar population density, it has to be kept in mind that data were available on different administrative levels, which may have caused some bias. Since population density was estimated with some degree of uncertainty, the effect of the bias caused by aggregating data originally obtained on different administrative levels is likely to be negligible. As wild boar population densities usually represent estimates, these data have always to be regarded as benchmarks rather than precise figures. However, currently these rough estimates of population densities based on hunting bag etc. are the only data available for analyzing wild boar population density data.

Due to the inclusion of all available samples in the analyses, the estimated periodic prevalences could be determined. The analyses of estimated ASFV genome prevalences during the study period showed hardly any change during the study period. This finding is in accord with other studies where the course of ASF in wild boar was analyzed and no significant change in the ASF prevalence in wild boar could be found over time[9,35]. The small variation in the prevalences did not indicate any seasonality of the ASF infection in wild boar. This is in contrast to studies conducted in the Russian Federation, Poland and Sardinia, where seasonality in the occurrence of ASF was found[35,37,38].

Only some of the control measures that had been implemented by the Latvian authorities during the study period could be analyzed with regard to their effect on the course of ASF. For measures that started shortly after

Age	ASFV genome detection	p	<0.001
		OR (95% CI)	0.55 (0.47–0.64)
	Serology	p	<0.001
		OR (95% CI)	0.72 (0.60–0.87)
	Carcass type (hunted/found dead)	p	<0.001
		OR (95% CI)	0.70 (0.60–0.82)
Carcass type (hunted/found dead)	ASFV genome detection	p	<0.001
		OR (95% CI)	192.51 (157.37–235.49)
	Serology	p	<0.001
		OR (95% CI)	9.30 (6.83–12.67)

Table 3. Associations between potential risk factors (age and carcass type) and a positive laboratory test result (ASFV genome detection and serology) and association between age and carcass type.

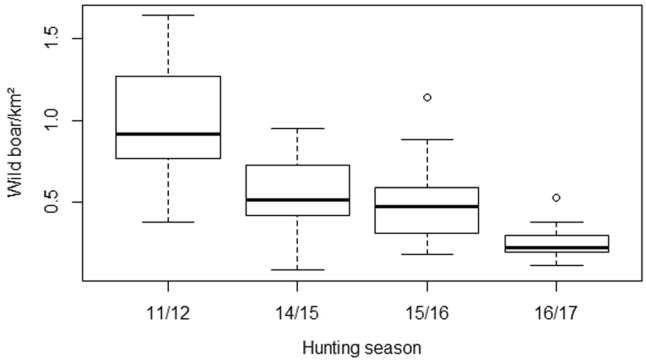

Figure 4. Temporal course of wild boar population density. Figure was generated by using the software package R (http://www.r-project.org).

the first ASF-positive wild boar had been detected in Latvia and were in place during the entire study period, e.g. the winter feeding ban (Table 1), an appropriate control time period could not be defined. Due to lack of transferability to other countries or areas, measures, in which only the allocation of responsibilities (e.g. veterinary authorities were responsible for collection of dead wild boar vs. hunters were responsible; C, D and E in Table 1) changed, were excluded from the analyses.

To analyze the effects of different control measures on the carcass type (hunted wild boar, animals found dead) or the estimated ASFV genome prevalence, a multivariable Bayesian regression model was used. Age and carcass type were statistically significantly associated with the estimated ASFV genome prevalence (Table 3). Therefore, accounting for the effect of age and either carcass type or estimated ASFV genome prevalence on the dependent variable, these variables were included in the model as fixed effects. Due to the low number of available geographical units, no spatial effect was included.

In contrast to most control measures, paying incentives to all persons who report dead wild boar to the veterinary authorities (control measure M1) and permission to use silencers and night vision devices for wild boar hunting (control measure M5) indicated a potential slight effect on the estimated ASF prevalence. Moreover, the number of hunted wild boar increased in the period, when control measure M5 was applied. The analyses of the effect of control measure M1 (incentives for notification of found dead wild boar) could not be separated from the analyses of control measure M5 (hunters could use silencers and night-vision device for wild boar hunting), because the control period of M1 corresponded to the period, when control measure M5 was applied. Therefore, the potential effect of M1 may be a result of M5 or vice versa. In addition, the combination of these measures may have also led to the observed results. The available data suggest that the wild boar population density decreased over time, presumably due to the increased hunting pressure which might have been supported by control measure M5 (usage of supporting tools). These results demonstrate the need to adapt hunting regulations in the case of the emergence of ASF or even before as a preventive measure in an area at risk. The permission to use these tools, however, does not necessarily indicate the extent of their use by hunters.

Paying incentives for hunted wild boar (M2) in the summer months of 2014 was mainly done to facilitate hunting. The season for driven hunts starts in October and the number of hunted animals therefore usually increases from this month onwards without any additional measures. Measure M2 showed no effect in the present study However, motivating hunters financially to reduce the population density might still support the control of ASF, as the wild boar population density probably plays an important role in the spread of ASF[8,9,15]. This applies especially to the summer months, during which the hunting activity is usually decreased.

As driven hunts end in February, restrictions regarding this form of hunting were only applied until February 2015 (M3a) and in a second period until February 2016 (M3b). The restrictions of driven hunts had no significant effect on the estimated ASFV genome prevalence. In both time periods when control measure M3 was

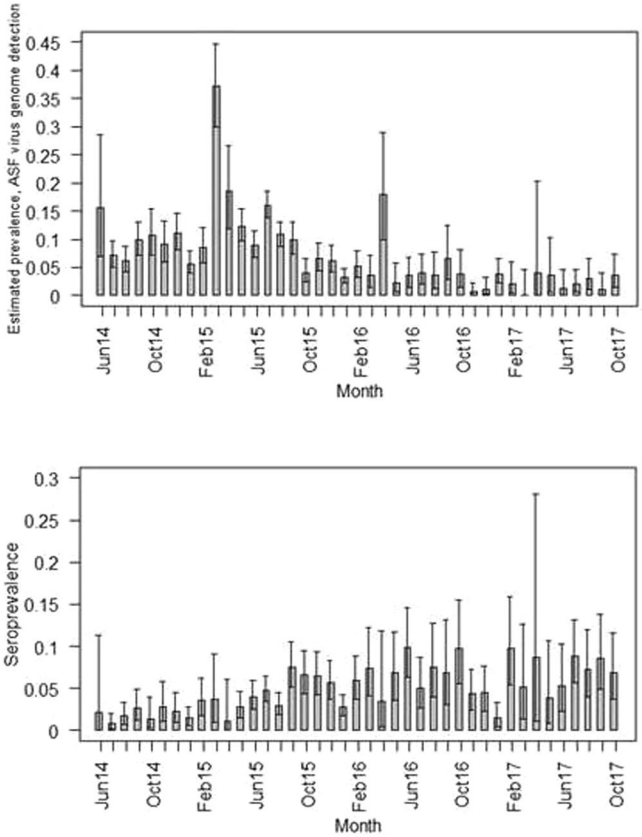

Figure 5. Estimated ASF prevalence (upper panel ASF virus genome detection by PCR; lower panel, detection of ASF-specific antibodies). The boxes represent point estimates and the whiskers 95% confidence intervals. Figure was generated by using the software package R (http://www.r-project.org).

Measure	Null hypotheses	Mean/ St.Dev.*
Incentives to all persons who report dead wild boar to the veterinary authorities (M1)	$H_0$1 No effect on the proportion of animals found dead	0.72
	$H_0$2 No effect on the estimated virus prevalence	1.20
Incentives to hunters for hunted wild boar (M2)	H_0 No effect on the proportion of hunted animals	0.65
Restrictions on driven hunts (M3a)	H_0 No effect on the estimated virus prevalence	0.61
Restrictions on driven hunts (M3b)	H_0 No effect on the estimated virus prevalence	0.58
Incentives for hunting adult and sub-adult female wild boar (M4a)	H_0 No effect on the proportion of hunted animals	0.09
Incentives for hunting adult and sub-adult female wild boar (M4b)	H_0 No effect on the proportion of hunted animals	0.78
Permission to use sound moderators (silencers) and night vision devices for wild boar hunting (M5)	$H_0$1 No effect on the proportion of hunted animals	1.71
	$H_0$2 No effect on the estimated virus prevalence	1.30

Table 4. Results of the multivariable analyses regarding the effects of the control measures on the estimated ASFV genome prevalence, the proportion of hunted animals or found dead. *Mean/Std.Dev. >1.96, indicating statistical significance.

implemented, the estimated ASFV genome prevalence was even higher than in the respective control periods. These findings contradict the hypothesis that driven hunts increase the risk of spreading ASF, as infected wild boar might be disturbed, driven apart and stimulated to move in a wider radius as usual.

Control measures 4a and 4b consisted of paying incentives for hunted female wild boar. Due to ethical considerations (hunting restrictions during the time of wild boar reproduction), no incentives were paid from March 2016 to September 2016. The implementation of control measure M4a led to an increase of the number of hunted wild boar, but the effect of the measure was not statistically significant, when age and prevalence were taken into account. When control measure 4b was in place, the incentives were lower than during the period, when control measure 4a was applied. This was simply to reduce expenses as limited funds were available. Although control measure 2, which was implemented in summer 2014, already included paying incentives for hunted wild boar, the payments only started again in November 2015. At that time, it had become obvious that ASF continued to spread. Accordingly, the European Commission decided to provide Latvia financial support to reduce the wild

boar population more intensively. Statistical analysis showed that similar to 2014, paying incentives had a direct positive effect on the proportion of hunted wild boar.

None of the control measures applied in Latvia during the present ASF epidemic showed a statistically significant effect on the relevant target variable (increase of the number of hunted wild boar or wild boar found dead). Also, no significant effect on the estimated ASF prevalence could be observed. However, when interpreting the results, the partly low sample size has to be considered. Especially the samples showing a positive test result for ASFV were often very small (Supplementary information Table S1) and a decrease of the effect size due to a small sample size could therefore not be excluded.

Over the study period of 41 months, the prevalence failed to decrease significantly, irrespectively of the implemented measures. Therefore, analyzing surveillance data, this study demonstrates what many experts had already feared and what also became evident in other affected countries: Once ASF has emerged in the wild boar population in a region, it seems hard or even impossible to eradicate the disease, at least if the epidemic is not stopped very early on. However, any potential long-term effects of the control measures remain unknown. A minor or moderate decrease of the ASF incidence in the wild boar population over several years due to the implemented control measures is still possible. Also Lange[15] stated that an effect on the course of ASF and the population will probably take many years. However, due to available data, in the present study the effects were only investigated for the measure and the defined control period.

Recent analyses of unpublished surveillance data suggest that the proportion of wild boar samples that tested positive for antibodies to ASFV but negative for ASFV genome by PCR increases in Latvia. This may indicate a decrease in the incidence of ASF in wild boar[39,40].

Our findings also demonstrate that more detailed knowledge on the transmission and excretion of ASFV, the tenacity in wild boar carcasses and on the role of potential carriers is necessary[40]. Once the epidemiology of the disease in the wild boar population becomes clearer, it might be possible to improve control measures and to utilize them in a more targeted way. Also, alternative measures such as fencing, which were used in controlling an epidemic of ASF among wild boar in the Czech Republic, need to be considered. Further studies are required to verify the success of such alternative control measures but also to investigate the possible long-term effects of measures that were already applied.

Although the effect of the wild boar population density on the course of an ASF epidemic remains disputed[8,9,16], additional strategies to reduce the wild boar population density should be taken into account (e.g. intensive targeted hunting on adult females or trapping). However, finally the question remains, whether affected countries will have to accept the presence of ASF within their wild boar population at a certain level and how they and their trade partners can learn to live with this situation. It may therefore be inevitable to focus on the biosecurity of pig farms. Unaffected countries should carefully evaluate their surveillance with the aim of preventing ASF entry and early detection in the case of ASF introduction[41].

Data Availability

In accordance with the responsible persons from Latvia, the original data used for the analyses can be obtained from the author.

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Author Contributions

K.S. designed the study, performed the data analyses and drafted the manuscript. E.O. designed the study, provided surveillance data and information about control measures and reviewed the manuscript. C.S. designed the study, supported the statistical analyses and reviewed the manuscript. K.L. provided input to the ASF situation in Latvia and reviewed the manuscript. M.S. provided hunting and wild boar population data and reviewed the manuscript. S.C. prepared a description of laboratory methods used for ASF diagnostics and reviewed the manuscript. F.J.C. supported the study with epidemiological considerations and carefully reviewed the manuscript. C.S.-L. designed and supervised the study and reviewed the manuscript.

Additional Information

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ORIGINAL ARTICLE

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African swine fever in Latvian wild boar—A step closer to elimination

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Abstract

In 2014, African swine fever (ASF) emerged in Latvia for the first time. The majority of cases appeared in wild boar, but the presence of ASF in these animals constitutes a permanent threat to domestic pig holdings. Recent studies have shown an increase in serologically positive and a decrease in PCR-positive ASF cases in wild boar, possibly indicating a decline of ASF incidence. We aimed to investigate the course of the ASF epidemic in wild boar in Latvia, thus attaining further insights into the ASF epidemiology in this country with the goal of assessing the stage of the epidemic. Latvian ASF surveillance data of wild boar were utilized to estimate the seroprevalence and ASF virus (ASFV) prevalence in the wild boar population. Prevalence estimates were obtained for both the eastern and western part of the country and in addition for the 2014/2015 to 2018/2019 hunting seasons. Moreover, prevalence estimates for three different age classes were calculated. An increase in serologically positive yet PCR-negative wild boar samples from active surveillance was identified over time. When comparing the age groups, wild boar younger than one year displayed the ASFV prevalence to be higher than the seroprevalence, whereas older animals shared higher seroprevalence estimates. These findings support the assumption that only a small proportion of affected animals survive an infection, leading to an accumulation of their numbers over time. As a result, ASF elimination in a country with an infected wild boar population could possibly be achieved, if effective wild boar population management and surveillance is maintained and combined with the detection and removal of wild boar carcasses to reduce the viral load in the environment. In addition, the wild boar population should be kept as small as possible to break the ASFV infection cycle.

KEYWORDS

African swine fever, epidemiology, Latvia, prevalence, serology, wild boar

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1 | INTRODUCTION

African swine fever (ASF) is a serious viral disease of domestic pigs and Eurasian wild boar (*Sus scrofa)* caused by African swine fever virus (ASFV) and generally associated with vast socio-economic impact in affected regions (Stahl et al., 2019). After the emergence of ASF in Georgia during 2007, the epidemic reached the first countries of the European Union at the beginning of 2014. In January 2014, the first cases were detected in Lithuania, the southern neighbour of Latvia (Pautienius et al., 2018), followed shortly after (February 2014) by the identification of the first ASF cases in Poland (Smietanka et al., 2016). In Estonia, bordering Latvia in the North, the epidemic started in September 2014 (Nurmoja et al., 2018). Almost three months prior to the Estonian outbreak, Latvia had reported the first cases of ASF in wild boar. It is very likely that the virus was introduced from neighbouring countries (Oļševskis et al., 2016). Until mid-2016, the eastern part of the country was mainly affected. However, in summer 2016, ASF reached the central area of Latvia and continued to spread towards west Latvia. This long-distance jump of ASFV may have been caused by human activities. Since 2016, the disease continued to spread slowly in the local wild boar population. In October 2019, ASF-infected wild boar were present in around 85% of Latvia.

Similar to other affected countries, ASF infection cycle in Latvia is maintained by wild boar (Oļševskis et al., 2016; Pautienius et al., 2018; Pejsak et al., 2018). Before the ASF outbreak, wild boar were the most popular and abundant large game in Latvia, representing nearly 70% of the ungulates hunted per year and playing an important role in trophic cascades. Supplementary feeding, selective shooting and restrictions in the use of hunting rights maintained the population. Concurrently, wild boar had become a conflict species, primarily due to the damage to agriculture and rural infrastructure caused by the animals. Targeted campaigns to reduce the wild boar population nationwide were introduced twice—in the first half of the 1990s and after 2014. Both times, the hunting rates were increased and targeted to females as all age classes of females are known to be highly reproductive and subsequently contribute to a fast increase in population sizes. In the 1990s, the wild boar depopulation measures were rather declarative and formally implemented. However, the numbers of wild boar declined drastically anyway after a harsh winter in 1995/1996 and large outbreaks of classical swine fever (CSF). After the beginning of the 21st century, the population rapidly recovered and reached a new maximum with an estimated population of approx. 74,000 individuals in 2013 (Andersone-Lilley, Balčiauskas, Ozoliņš, Randveer, & Tõnisson, 2010; Kawata, Ozolins, & Baumanis, 2013). At the end of the 2018/2019 hunting season, the estimation comprised only approx. 20,000 wild boar (https://www.zm.gov.lv/public/files/CMS_Static_Page_Doc/00/00/00/85/05/Mezacukasdinamika.jpg).

Due to the transmission potential, ASF-infected wild boar represent a threat for the domestic pig industry. In addition, controlling ASF in wild boar populations has been proven more difficult than eliminating the virus from affected pig farms (Gogin, Gerasimov, Malogolovkin, & Kolbasov, 2013; Nurmoja et al., 2017; Schulz, Oļševskis, et al., 2019).

After 2 years with a growing epidemic, in most countries with comprehensive surveillance data, an increase of ASFV PCR-positive wild boar samples was observed (European Food Safety Authority, Gogin, Richardson, & Gervelmeyer, 2017). Most surveillance samples were retrieved by passive surveillance, that is from animals found dead, shot due to sickness or killed in a road traffic accident (European Food Safety Authority et al., 2017; Nurmoja et al., 2017; Pautienius et al., 2018). However, recent analyses suggest a decline in the incidence of PCR-positive wild boar in some countries, while the prevalence of seropositive wild boar (mainly hunted wild boar showing positive laboratory test results for antibodies against ASFV) increased simultaneously (Schulz, Staubach, et al., 2019). Following the assumptions of Schulz, Staubach, et al. (2019), this may indicate a decline of the ASF epidemic in these countries. A long period of detectability of ASFV antibodies was found in domestic pigs (Penrith et al., 2004; Pujols Romeu, Badiola Saiz, Perez de Rozas, Rosell Bellsola, & Carreras Mauri, 1991), and similar values can be assumed in wild boar. Therefore, it can take several years of surveillance without new virus introduction until no seropositive cases are detected.

The difficulties in controlling ASF in wild boar and the long time period, during which the virus has been circulating in the wild boar population in several countries, emphasize the continuing need of further epidemiological research to understand the course of ASF in wild boar populations (Depner et al., 2016; European Food Safety Authority, 2018, 2020; Gogin et al., 2013). Additionally, ASF continues to spread to further countries, thus increasingly threatening the global pig market. Expanding the knowledge on ASF in wild boar can therefore help to improve control and the effectiveness of surveillance. The detailed research regarding seropositive wild boar and their role in the course of ASF might support the certainty regarding the disease status of a country and thus, in the best case, decrease the economic damage caused by ASF.

The present study aimed to analyse ASFV prevalence and seroprevalence estimates as well as describe the course of ASF in wild boar in Latvia. The results could be compared with those from other countries with the ultimate goal of assessing the epidemiological situation of ASF in wild boar populations in the best possible way.

2 | MATERIALS AND METHODS

2.1 | Study area

According to national legislation (Regulation of the Cabinet of Ministers No 274, 28 April 2004) (https://likumi.lv/doc.php?id=88074), Latvia is divided into six statistical regions: Riga (304 km^2), Pieriga (10,134 km^2), Zemgale (10,732 km^2), Kurzeme (13,606 km^2), Latgale (14,550 km^2) and Vidzeme (15,245 km^2). Because of the high proportion of urban areas, the region of Riga was excluded from the analyses. Due to the slow spread of ASF from the East to the West of Latvia, we divided the country into an

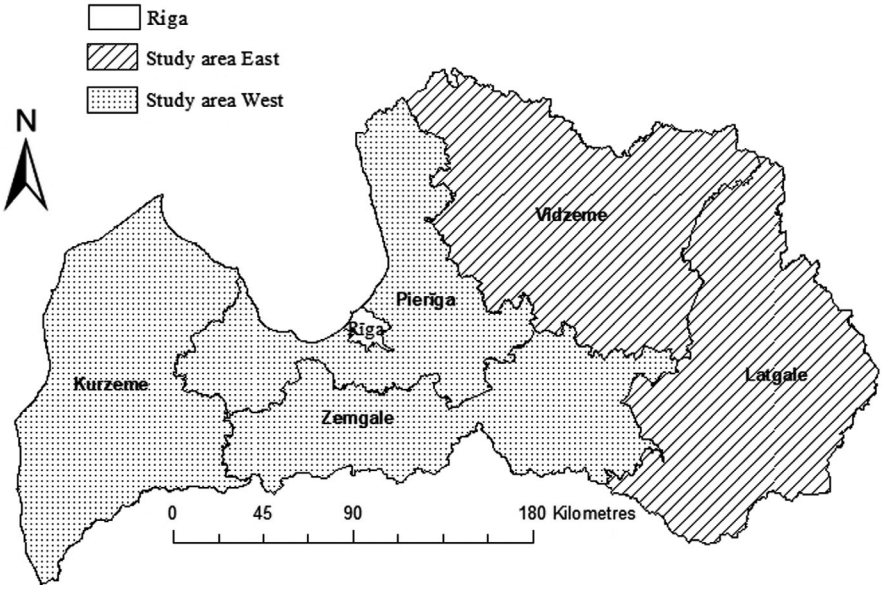

FIGURE 1 The six statistical regions of Latvia grouped into an eastern and western part of Latvia. Riga was excluded from the analysis due to its mainly urban character

eastern (Latgale and Vidzeme) and a western (Pieriga, Zemgale and Kurzeme) section (Figure 1).

2.2 | Data description

Data from five consecutive hunting seasons (2014/2015–2018/2019) were available for the analysis. In Latvia, the hunting year lasts from 1 April to the 31 March of the following year. Surveillance data were used from the CSF/ASF wild boar surveillance database of the European Union (https://surv-wildboar.eu). The structure of the data sets has previously been described (Schulz, Staubach, et al., 2019). In brief, the origin of each sample was recorded, including information on the source, that is active surveillance (hunted wild boar) or passive surveillance (wild boar found dead, involved in a road traffic accident or shot due to sickness). In addition, each data set included information about the age of the sampled animal categorized in three groups (<1 year, 1–2 years, >2 years).

For analyses, all data records containing no clear PCR result (positive or negative) were excluded. Also, data records originating from passive surveillance and tested serologically (i.e. for antibodies against ASFV) were excluded from the final analyses. For age analyses, all data records that lacked information on the age of the respective wild boar were excluded.

In the course of passive surveillance, tissue samples (organs, mainly bone marrow) were taken from animals by veterinary inspectors or state-authorized veterinarians and analysed by PCR.

For active surveillance, blood samples were taken by trained hunters from each hunted wild boar and submitted for the detection of ASFV genome and ASFV antibodies.

Passive surveillance was conducted throughout Latvia starting in June 2014. Active surveillance included the sampling of all hunted wild boar in a radius of 8–20 km around every newly discovered ASF wild boar case. The size of the areas covered by active surveillance progressed correspondingly with the ASFV spread in the wild boar population. The laboratory procedures for detecting ASFV genome via PCR or antibodies via ELISA have been previously described (Schulz, Oļševskis, et al., 2019).

2.3 | Data analysis

PCR-positive samples, regardless of their serological result (i.e. the sample could have shown either a seropositive, a seronegative or no serological test result), were summarized (group 1) as described (Schulz, Staubach, et al., 2019). The prevalence of wild boar showing these test results was calculated based on the total number of animals tested by PCR. In group 1, samples from active and passive surveillance were included.

Following the same procedure, samples that yielded a seropositive but PCR-negative test result were grouped together (group 2). Therefore, the seroprevalence (i.e. prevalence of wild boar with antibodies against ASFV) was calculated based on the total number of animals tested by PCR and ELISA, regardless of the test result. All samples used for the calculations for group 2 originated from active surveillance.

Although the focus was put on analysing and comparing groups 1 and 2, samples with a PCR-positive and simultaneously a seropositive result (group 3) and samples exclusively PCR-positive but seronegative (group 4) were analysed for the sake of completeness. Both groups included samples originated from hunted animals (active surveillance).

As in group 2, the prevalence of wild boar tested PCR-positive and seropositive (group 3) or PCR-positive but seronegative (group 4) were also calculated based on the total number of wild boar that had shown unambiguous PCR and serological test results (i.e. either positive or negative).

For all four groups, prevalence estimates were obtained for each age class (<1 year, 1–2 years and >2 years), for the five study

regions, area East and area West, and for all hunting seasons. For group 1, the prevalence depending on the source of the samples, that is active or passive surveillance, was also determined for each area and hunting season. To describe the course of the prevalence in each hunting season and in each study area, confidence intervals were calculated according to Clopper and Pearson (1935). All calculations were done using the software package R (http://www.r-project.org) (R Core Team, 2015), also used to produce the included figures.

3 | RESULTS

3.1 | Data description

After excluding all data records with an inconclusive PCR result (n 251) and data records originating from passive surveillance and with a serological test result (n 423), 60,166 data records were available for analysis (Appendix Table A1). Data records with no age information were removed from the age analyses (n 1,622).

In all areas, most samples originated from animals between 1 and 2 years old. The number of samples resulting from active surveillance was clearly higher than samples from passive surveillance (Figure 2, Appendix Table A1).

The number of samples obtained in the western regions of Latvia was slightly lower than those from the eastern regions, but the differences in samples sizes were not significant. The number of tested wild boar samples from the area East peaked in the 2015/2016 hunting season, whereas the sample size increased in the area West over time and reached a peak in the 2017/2018 hunting season (Figure 2, Appendix Table A1).

3.2 | Data analysis

Group 1: In group 1, all samples with a positive ASFV PCR result were aggregated, regardless of the serological result (negative, positive or not tested). In both the eastern and western areas, the prevalence was highest in the subset of animals younger than 1 year (mean prevalence East: <1 year: 0.048, 1–2 years: 0.033, >2 years: 0.020; mean prevalence West: <1 year: 0.063, 1–2 years: 0.037, >2 years: 0.037) (Figure 3). This was in accordance with the results obtained for each of the five study regions individually (Appendix Table A2).

In both study areas and all hunting seasons, the prevalence estimates for hunted or found dead wild boar showing results in accordance with group 1 were significantly higher (approx. 35 times higher) in wild boar sampled through passive surveillance than those sampled through active surveillance (Figure 4, Appendix Table A6).

Group 2: In group 2, all samples with a seropositive and an ASFV PCR-negative test result were combined. In contrast to group 1, no significant differences in the prevalence estimates between the different age classes were observed, although the mean prevalence of seropositive animals was higher in wild boar older than 2 years (mean prevalence East: <1 year: 0.024, 1–2 years: 0.025, >2 years: 0.035; mean prevalence West: <1 year: 0.020, 1–2 years: 0.016, >2 years: 0.020). However, especially in the East during the last hunting season, the samples with a seropositive result were significantly higher in animals older than 2 years (<1 year: 0.007 (CI: 0.003–0.014), 1–2 years: 0.027 (CI: 0.020–0.036), >2 years: 0.059 (CI: 0.046–0.074)) (Figure 5, Appendix Table A3).

Although the seroprevalence in the East at first increased, a decline was later observed during the 2017/2018 and 2018/2019 hunting

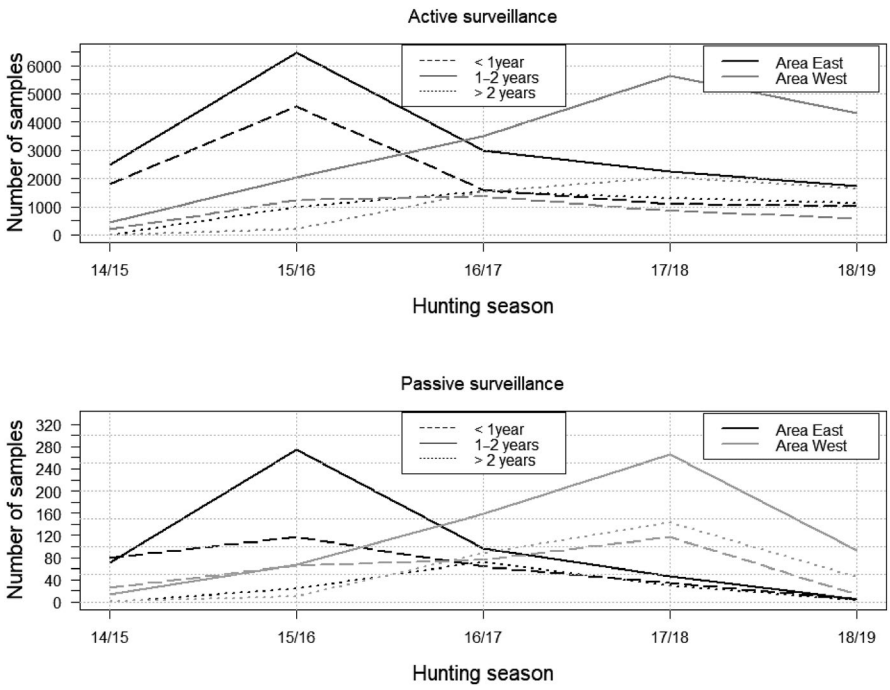

FIGURE 2 Number of samples originating from active or passive surveillance in area East and area West, stratified for three different age classes (<1 year, 1–2 years, >2 years)

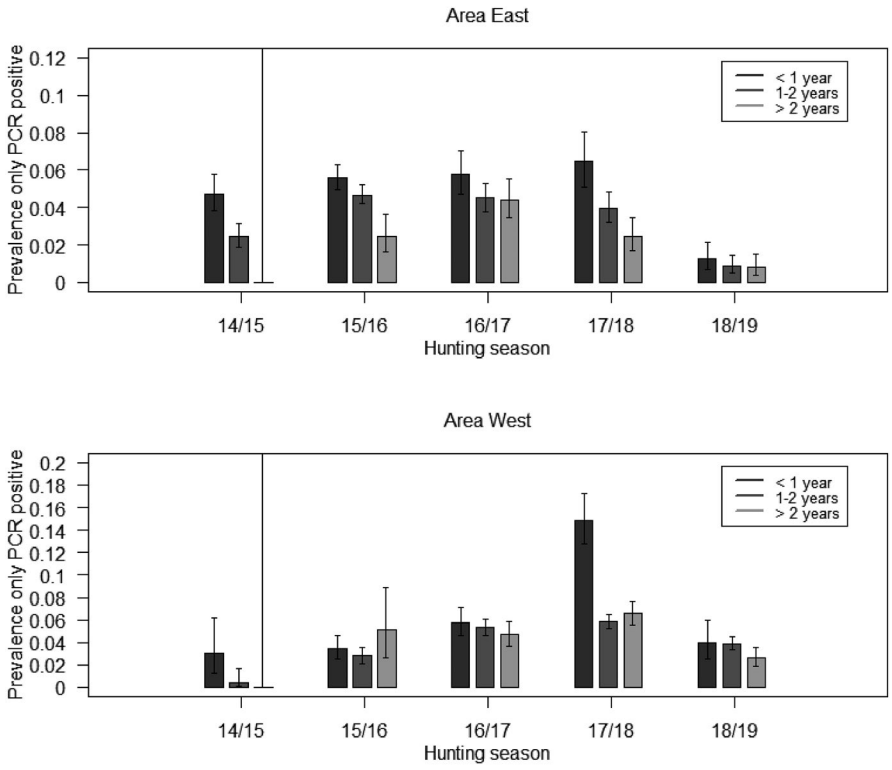

FIGURE 3 Prevalence estimates for ASFV PCR-positive samples, irrespective of their serological test result, stratified by age class, study area East and West and hunting season. The whiskers indicate 95% confidence intervals.

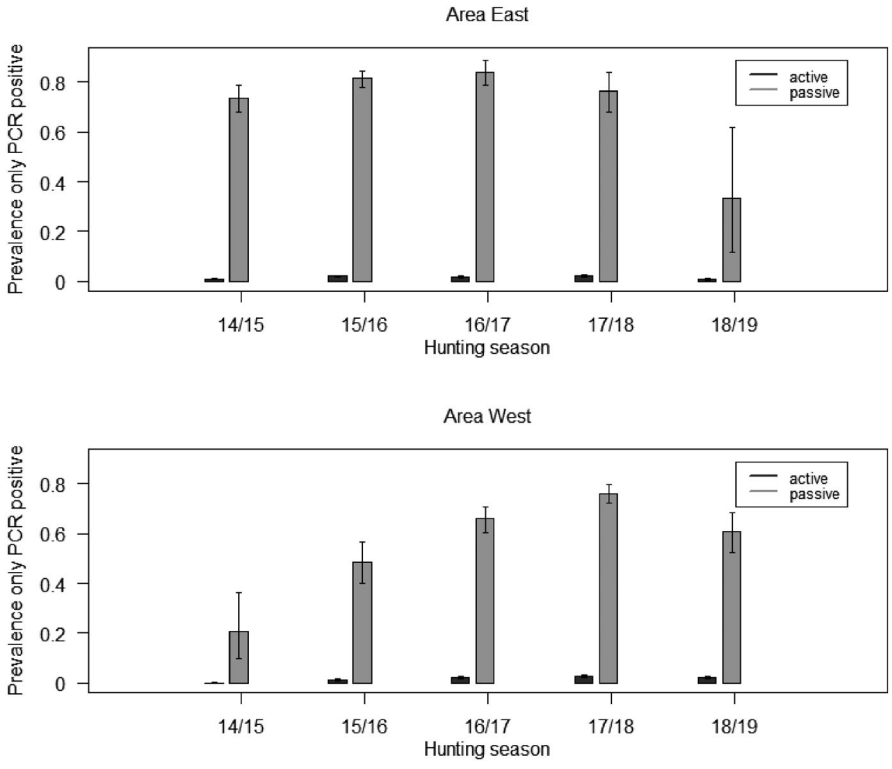

FIGURE 4 Prevalence estimates for ASFV PCR-positive samples, irrespective of their serological test result, stratified by the origin of sample (active or passive surveillance), the study areas East and West, and the five hunting seasons. The whiskers indicate 95% confidence intervals

seasons. This trend was observed in all three age classes. In the West, the average prevalence for each age class was lower than in the eastern area. Nevertheless, an increase over time was also observed, but the highest seroprevalence in the West was not observed before 2018/2019 hunting season in all age classes (Figure 4, Appendix Table A3).

Group 3: In group 3, all samples with a positive ASFV PCR and a seropositive test result were analysed. Generally, the prevalence estimates were very low for hunted wild boar yielding samples from group 3. In areas East and West, the highest prevalence was found in samples obtained from animals younger than 1 year (max.

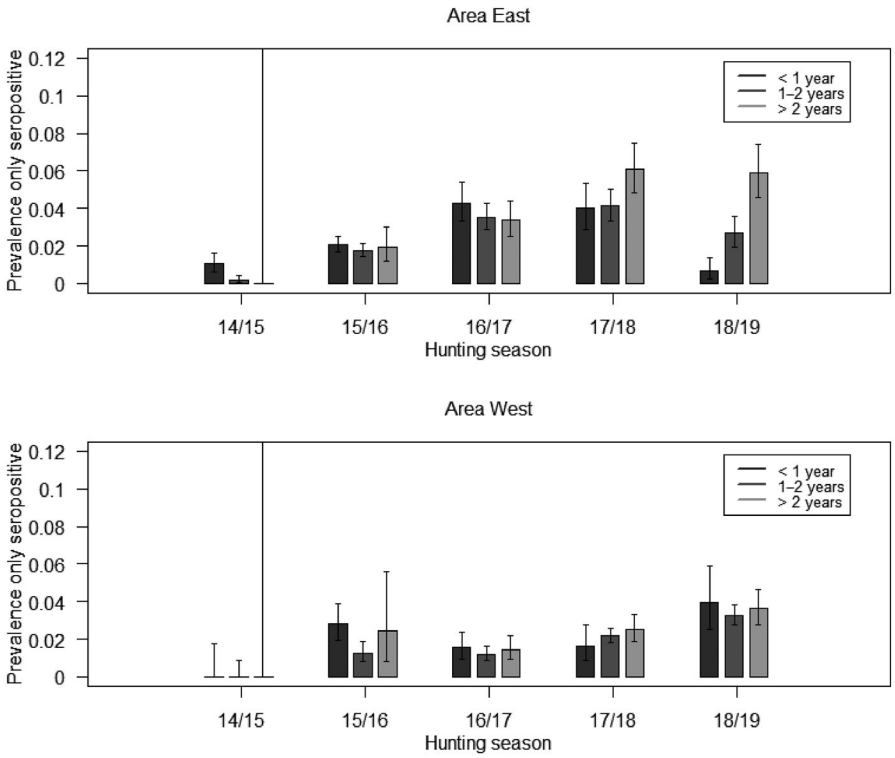

FIGURE 5 Prevalence estimates for ASFV antibody-positive samples, stratified by three different age classes, the study areas East and West, and the five hunting seasons. The whiskers indicate 95% confidence intervals

prevalence 0.025). In both regions, the prevalence estimates were similar. Towards the end of the observation period, that is hunting season 2018/2019, a slight decrease was observed (Appendix Table A4).

Group 4: In group 4, all samples with an ASFV PCR-positive and a seronegative test result were analysed. Corresponding with the previous groups, the prevalence estimates were highest in animals younger than 1 year. This applied particularly to the eastern regions of Latvia (max. prevalence 0.026). Similar to group 3, the differences in the prevalence estimates between the two study areas were not significant. Moreover, the prevalence estimates decreased in both areas over time (Appendix Table A5).

4 | DISCUSSION

The Latvian wild boar population has now suffered from ASF for five consecutive years. During this time, the disease has spread from the eastern part of the country towards the West. For our analyses, the country was therefore divided into two geographically distinct study areas, East and West, to understand the temporal stages of the ASF epidemic. Both areas exhibited a different course of the disease, which therefore had to be taken into account in the epidemiological analysis. Additionally, analysing the data at the regional level allowed us to compare the course of ASF in wild boar in the different regions during the hunting seasons.

When comparing the results for the chosen study areas, the differences in size and any potentially resulting differences in sample numbers had to be taken into consideration. Despite the larger size of area West, the number of samples taken at the beginning of the study period as part of active and passive surveillance was clearly higher in the East (hunting seasons 2014/2015 and 2015/2016). Yet, in the last two hunting seasons, the sample size in the West overtook the number of samples in eastern area. This can be explained by the mandatory intensification of surveillance (particularly of active surveillance) after a region, in this case area West, is affected by ASF. Similar observations were made in other countries (Nurmoja et al., 2017). These findings also illustrate the need to enhance surveillance not only when ASF is present, but before its arrival (Nurmoja et al., 2017). On the other hand, a decrease in sample sizes was seen in area East over time. This might be mainly due to a decrease in the wild boar population density, a possible consequence of ASF, its high case-fatality ratio and increased hunting efforts (Schulz, Oļševskis, et al., 2019; Schulz, Staubach, et al., 2019). In contrast to the reported approx. 74,000 wild boar in 2013 (Andersone-Lilley et al., 2010; Kawata et al., 2013), the estimated wild boar population in Latvia was approximately 20,000 individuals at the end of the hunting season 2018/2019. The decrease in population density and thus also in the number of detectable wild boar carcasses might indicate that the epidemic has reached the deceleration phase as defined in the EU working document 'Strategic approach to the management of African Swine Fever for the EU' (SANTE/7113/2015—Rev 11). However, regardless of the reasons for the decrease in population density, as long as ASF is present, as is still the case in Latvia and in some of its neighbouring countries, effective hunting and surveillance must be maintained (European Food Safety Authority, 2020). These measures should be combined with effective detection and

removal of wild boar carcasses, thus reducing the viral load in the environment (European Food Safety Authority, 2018, 2020). Moreover, the wild boar population should be kept as small as possible in order to potentially break the ASFV infection chain (European Food Safety Authority, 2018, 2020; Gavier-Widen et al., 2015; Lange, 2015). Reliable surveillance must be kept in place to detect new entries or further spread of the disease. This applies particularly to passive surveillance, known to represent the most effective way of detecting ASF in wild boar (European Food Safety Authority, 2018; Nurmoja et al., 2017; Schulz, Oļševskis, et al., 2019). Due to the difficulties in finding dead wild boar and the low acceptability among hunters to support passive surveillance (Schulz, Calba, Peyre, Staubach, & Conraths, 2016), the number of samples obtained by passive surveillance was much lower than those received through active surveillance. However, the temporal trend was similar, demonstrating the importance of keeping hunters motivated in regard to supporting passive surveillance. In all regions and hunting seasons, most samples were unsurprisingly obtained from 1- to 2-year-old animals, as this age class represents the typically hunted target group (European Food Safety Authority, 2015; Schulz et al., 2016; Toigo, Servanty, Gaillard, Brandt, & Baubet, 2008).

In the present study, we assumed that samples from ASF-infected wild boar are positive by PCR a few days post-infection, stay positive by PCR and also yield a seropositive test result for up to approximately 100 days and finally remain exclusively seropositive for an undetermined period (Petrov, Forth, Zani, Beer, & Blome, 2018; Schulz, Staubach, et al., 2019; Zani et al., 2018). For domestic pigs, this period was described to last several years (Penrith et al., 2004; Pujols Romeu et al., 1991). Test results were therefore analysed in several groups, taking into account that animals in group 1 were infected within 100 days prior to sampling, whereas animals in group 2 had survived an ASF infection. Due to the decomposition of carcasses, blood samples could often not be taken from animals found dead. Therefore, samples originating from passive surveillance are usually not tested for antibodies against ASFV. Very rarely, fresh samples were obtained from wild boar shot due to sickness or killed in road traffic accidents. These samples were tested for antibodies against ASFV; however, considering the rarity of these events, we excluded all data originating from ASFV antibody testing via passive surveillance, thus avoiding confusion and misinterpretation of the study results.

Based on the grouping of wild boar samples depending on their test results, we aimed to assess the epidemiological stage of the ASF epidemic in Latvia during the five different hunting seasons. While interpreting the study results, it must be acknowledged that factors like wild boar population density or ASF control measures might influence the ASF prevalence estimates in the different hunting seasons (European Food Safety Authority, 2018; Lange, 2015; Smietanka et al., 2016). In Estonia, a decrease of PCR-positive wild boar and an increase of seropositive wild boar over time was observed. At the same time, the population density decreased, possibly due to ASF and the implemented measures to control ASF in wild boar (Schulz, Staubach, et al., 2019). Due to the descriptive character of the study design, these factors and their potential influence were not included. However, also in Latvia, the assumption still stands that the decreasing population density and the long-term effects of control measures influenced the course of ASF (Schulz, Oļševskis, et al., 2019). Moreover, the data were only analysed in connection with the respective hunting season, permitting the comparison of the results from the individual hunting seasons.

Similar to Estonia (Schulz, Staubach, et al., 2019), the results showed after an initial increase as described by the European Food Safety Authority et al. (2017), a decrease in the ASFV prevalence in all wild boar samples over time. Simultaneously, an increase in the seroprevalence in hunted wild boar was detected as previously described by the European Food Safety Authority (2020). Moreover, the differences of the prevalence estimates of group 1 and group 2 between the hunting seasons indicated a time shift between area East and area West, similar to the situation in Estonia. Both prevalence estimates showed a comparable course over time, but particularly the increase in seroprevalence occurred later on in the western part of Latvia. In eastern Latvia, the seroprevalence started to decline in the 2018/2019 hunting season, suggesting the beginning of disease elimination in that area, while the seroprevalence peaked in the West during the same season, indicating the phase of a decreasing epidemic. This course of disease can be explained by the slow spread of ASF from eastern to western parts of Latvia and correspond with the results published by the European Food Safety Authority (2020). The very low prevalence of ASFV in east Latvia and the decrease of the seroprevalence towards the end of the study period are promising findings and may imply the slow disappearance of ASF.

Although western Latvia was affected by ASF from 2016 onwards, the disease had already been circulating for over a year in the East. Analyses of the prevalence estimates for groups 3 and 4, including samples from newly infected hunted animals (infected within the last 100 days prior to sampling), support these results. The prevalence estimates also decreased over time, in the East slightly earlier than in the West. In both areas, the prevalence estimates for these groups were very low and showed the highest values in wild boar younger than one year. In accordance with findings from other researchers, these findings provide no evidence for the presence of long-term virus carriers (Stahl et al., 2019).

ASFV PCR-positive samples (group 1) reached the highest prevalence in wild boar younger than 1 year. This is in line with the finding that the ASFV prevalence showed the highest values in animals between 1 and 2 years, but without a significant difference relative to animals younger than 1 year (European Food Safety Authority, 2015). In addition to the finding that the prevalence of ASFV PCR-positive samples was increased in younger animals, it was obvious that the prevalence of ASFV PCR-positive animals was much higher when the tested samples were obtained by passive surveillance (in comparison with samples received through active surveillance, i.e. hunting of apparently healthy wild boar). Both findings may be explained

by the high case-fatality ratio (Schulz, Conraths, Blome, Staubach, & Sauter-Louis, 2019). In addition, these findings once again illustrate the vast difference in the chances of early ASF detection in wild boar found dead (high chance) versus in hunted wild boar (low chance) (European Food Safety Authority, 2018; European Food Safety Authority et al., 2017; Nurmoja et al., 2017; Schulz, Oļševskis, et al., 2019).

The significantly higher values in the seroprevalence estimates (group 2) in hunted animals older than 2 years in the last two hunting seasons of area East might be due to the accumulation of surviving wild boar over time. They simultaneously suggest a decline of the ASF incidence in the eastern part of Latvia (European Food Safety Authority, 2020; Schulz, Staubach, et al., 2019).

In several previous studies, the role of ASF survivors and their potential for spreading ASFV was intensively discussed (European Food Safety Authority, 2015; Gallardo et al., 2018; Petrov et al., 2018; Schulz, Staubach, et al., 2019). However, so far no hard evidence was found to prove the infectiousness of wild boar tested seropositive, but PCR-negative (Stahl et al., 2019). Therefore, this comprehensive description of Latvian surveillance data of the last 5 years provides a glimpse of hope for successful control or even potential elimination of ASF in wild boar, despite the huge difficulties that must be overcome, when combating ASF in these animals. In accordance with the long period of detectability of antibodies found in domestic pigs (Penrith et al., 2004; Pujols Romeu et al., 1991), wild boar most likely follow the same immune response pattern. Therefore, the continuous detection of seropositive animals does not indicate any new virus introduction or circulating virus, but instead the expected findings point towards a subsiding epidemic. Although these findings suggest a potential end of the epidemic, the high efforts to monitor the epidemiological situation of ASF in wild boar continuously have to be maintained. Also, due to the continuous high risk of infection from infected neighbouring countries it is of upmost important, especially at this stage, to cautiously analyse the epidemiological situation of ASF in the wild boar population in Latvia to adjust control measures where necessary and reach final elimination.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest.

AUTHOR CONTRIBUTIONS

E.O. designed the study, performed the analysis and drafted the manuscript; K.S. supported and finalized the analysis and drafted the manuscript; C.S. supported the analysis and reviewed the manuscript; M.S. supported the design of the study and reviewed the manuscript; K.L. designed the study together with E.O. and supported the drafting of manuscript; D.P. provided and analysed the data; J.O. reviewed the manuscript and provided information on wild boar population status before and after ASF introduction; F.C. carefully reviewed the analyses and the manuscript; and C.S.L. supervised the study and the analyses and reviewed the manuscript.

ETHICAL APPROVAL

The authors confirm that the ethical policies of the journal, as noted on the journal's author guidelines page, have been adhered to. No ethical approval was required as no animal experiments were conducted.

DATA AVAILABILITY STATEMENT

The original data used for the analyses can be obtained from the author after approval by the responsible institution in Latvia.

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APPENDIX

TABLE A1 Numbers of samples per study area, hunting season, age class and origin of carcass

	Latgale						Vidzeme					
	<1 year		1–2 years		>2 years		<1 year		1–2 years		>2 years	
	A	P	A	P	A	P	A	P	A	P	A	P
2014–2015	1,260	35	1,649	29	1	0	539	45	829	41	1	0
2015–2016	1,591	29	2,273	59	431	9	2,959	88	4,191	216	556	15
2016–2017	1,004	19	1,194	25	723	21	595	45	1,808	71	822	51
2017–2018	592	15	1,020	20	708	14	490	20	1,219	26	597	15
2018–2019	543	5	816	2	516	3	490	0	908	3	591	1

Pieriga						Zemgale						Kurzeme					
<1 year		1–2 years		>2 years		<1 year		1–2 years		>2 years		<1 year		1–2 years		>2 years	
A	P	A	P	A	P	A	P	A	P	A	P	A	P	A	P	A	P
54	7	158	4	0	1	113	5	192	6	1	0	46	4	74	3	1	0
500	28	852	46	123	7	737	7	1,192	12	82	2	1	17	3	10	0	1
880	40	1,683	59	847	57	378	12	1,126	29	403	7	113	8	683	70	263	24
411	28	1,837	75	728	48	240	34	1,773	50	494	14	209	51	2,042	141	802	81
172	2	844	19	390	20	112	0	787	1	274	2	279	11	2,698	74	968	23

Area East						Area West					
<1 year		1–2 years		>2 years		<1 year		1–2 years		>2 years	
A	P	A	P	A	P	A	P	A	P	A	P
1,799	80	2,478	70	2	0	213	26	424	13	2	1
4,550	117	6,464	275	987	24	1,238	65	2,047	68	205	10
1,599	64	3,002	96	1,545	72	1,371	76	3,492	158	1,513	88
1,082	35	2,239	46	1,305	29	860	118	5,652	266	2,024	143
1,033	5	1,724	5	1,107	4	563	13	4,329	94	1,632	45

Note: A illustrates the number of samples originating from active surveillance (hunting of apparently healthy wild boar) and P from passive surveillance (found dead, shot sick or road traffic accident).

TABLE A2 Prevalence estimates and the 95% confidence interval of wild boar with an ASFV PCR-positive results, irrespective of the serological test result, stratified by region, hunting season and age class

	<1 year			1–2 years			>2 years		
	Prevalence	Lower 95% CI	Upper 95% CI	Prevalence	Lower 95% CI	Upper 95% CI	Prevalence	Lower 95% CI	Upper 95% CI
Latgale									
2014/2015	0.038	0.028	0.050	0.022	0.017	0.028	0.000	0.000	0.975
2015/2016	0.042	0.033	0.053	0.042	0.038	0.047	0.020	0.009	0.038
2016/2017	0.039	0.028	0.053	0.049	0.044	0.055	0.026	0.015	0.040
2017/2018	0.069	0.050	0.092	0.053	0.048	0.058	0.028	0.017	0.042
2018/2019	0.024	0.013	0.040	0.030	0.026	0.035	0.017	0.008	0.033
Vidzeme									
2014/2015	0.068	0.049	0.092	0.043	0.030	0.058	0.000	0.000	0.975
2015/2016	0.063	0.055	0.073	0.055	0.048	0.062	0.028	0.016	0.045
2016/2017	0.088	0.067	0.112	0.057	0.047	0.069	0.060	0.045	0.077
2017/2018	0.059	0.040	0.083	0.039	0.029	0.052	0.021	0.011	0.036
2018/2019	0.000	0.000	0.008	0.002	0.000	0.008	0.000	0.000	0.006
Pieriga									
2014/2015	0.066	0.018	0.159	0.000	0.000	0.023	0.000	0.000	0.975
2015/2016	0.070	0.050	0.095	0.055	0.041	0.072	0.069	0.032	0.127
2016/2017	0.073	0.057	0.092	0.051	0.041	0.062	0.055	0.041	0.072
2017/2018	0.125	0.096	0.160	0.049	0.039	0.059	0.058	0.043	0.077
2018/2019	0.046	0.020	0.089	0.037	0.025	0.052	0.017	0.007	0.035
Zemgale									
2014/2015	0.025	0.005	0.073	0.010	0.001	0.036	0.000	0.000	0.975
2015/2016	0.011	0.005	0.021	0.008	0.004	0.015	0.024	0.003	0.083
2016/2017	0.033	0.018	0.056	0.031	0.022	0.043	0.007	0.002	0.021
2017/2018	0.161	0.119	0.210	0.041	0.032	0.051	0.047	0.031	0.069
2018/2019	0.009	0.000	0.049	0.033	0.022	0.048	0.014	0.004	0.037
Kurzeme									
2014/2015	0.000	0.000	0.071	0.000	0.000	0.047	0.000	0.000	0.975
2015/2016	0.000	0.000	0.185	0.000	0.000	0.247	0.000	0.000	0.975
2016/2017	0.025	0.005	0.071	0.090	0.071	0.113	0.076	0.048	0.113
2017/2018	0.177	0.133	0.229	0.081	0.070	0.093	0.083	0.065	0.103
2018/2019	0.048	0.027	0.080	0.041	0.034	0.049	0.033	0.023	0.046
Area East									
2014/2015	0.047	0.038	0.058	0.025	0.019	0.032	0.000	0.000	0.842
2015/2016	0.056	0.050	0.063	0.047	0.042	0.052	0.025	0.016	0.036
2016/2017	0.058	0.047	0.070	0.045	0.038	0.053	0.044	0.034	0.055
2017/2018	0.064	0.051	0.080	0.039	0.032	0.048	0.025	0.017	0.035
2018/2019	0.013	0.007	0.021	0.009	0.005	0.014	0.008	0.004	0.015
Area West									
2014/2015	0.031	0.012	0.062	0.005	0.001	0.016	0.005	0.000	0.708
2015/2016	0.035	0.026	0.046	0.028	0.021	0.036	0.028	0.026	0.090
2016/2017	0.058	0.046	0.071	0.053	0.046	0.061	0.053	0.037	0.058
2017/2018	0.149	0.127	0.173	0.058	0.052	0.065	0.058	0.055	0.077
2018/2019	0.040	0.025	0.059	0.039	0.033	0.045	0.039	0.019	0.035

TABLE A3 Prevalence estimates of wild boar with an ASFV PCR-negative and a seropositive test results, stratified by region, hunting season and age class

	<1 year			1–2 years			>2 years		
	Prevalence	Lower 95% CI	Upper 95% CI	Prevalence	Lower 95% CI	Upper 95% CI	Prevalence	Lower 95% CI	Upper 95% CI
Latgale									
2014/2015	0.006	0.003	0.013	0.002	0.000	0.005	0.000	0.000	0.975
2015/2016	0.015	0.009	0.022	0.020	0.015	0.026	0.023	0.011	0.042
2016/2017	0.028	0.019	0.040	0.028	0.020	0.040	0.026	0.016	0.041
2017/2018	0.029	0.017	0.046	0.035	0.025	0.049	0.033	0.021	0.048
2018/2019	0.007	0.002	0.019	0.025	0.015	0.038	0.037	0.022	0.057
Vidzeme									
2014/2015	0.021	0.010	0.036	0.001	0.000	0.007	0.000	0.000	0.975
2015/2016	0.024	0.019	0.030	0.017	0.013	0.021	0.016	0.007	0.031
2016/2017	0.068	0.049	0.091	0.040	0.031	0.050	0.040	0.028	0.056
2017/2018	0.053	0.035	0.077	0.046	0.035	0.059	0.094	0.072	0.120
2018/2019	0.006	0.001	0.018	0.029	0.019	0.042	0.078	0.058	0.102
Pieriga									
2014/2015	0.000	0.000	0.066	0.000	0.000	0.023	0.000	0.000	0.066
2015/2016	0.055	0.037	0.079	0.024	0.015	0.037	0.055	0.037	0.079
2016/2017	0.011	0.005	0.021	0.017	0.011	0.024	0.011	0.005	0.021
2017/2018	0.012	0.004	0.028	0.016	0.011	0.023	0.012	0.004	0.028
2018/2019	0.047	0.021	0.091	0.038	0.026	0.053	0.047	0.021	0.091
Zemgale									
2014/2015	0.000	0.000	0.033	0.000	0.000	0.019	0.000	0.000	0.975
2015/2016	0.010	0.004	0.020	0.005	0.002	0.011	0.012	0.000	0.066
2016/2017	0.027	0.013	0.049	0.009	0.004	0.017	0.007	0.002	0.022
2017/2018	0.030	0.012	0.060	0.039	0.030	0.049	0.026	0.014	0.045
2018/2019	0.054	0.020	0.113	0.055	0.040	0.073	0.055	0.031	0.089
Kurzeme									
2014/2015	0.000	0.000	0.079	0.000	0.000	0.049	0.000	0.000	0.975
2015/2016	0.000	0.000	0.975	0.000	0.000	0.708	0.000	0.000	0.975
2016/2017	0.009	0.000	0.049	0.004	0.001	0.013	0.004	0.000	0.021
2017/2018	0.010	0.001	0.034	0.012	0.008	0.018	0.015	0.008	0.026
2018/2019	0.029	0.013	0.056	0.025	0.019	0.031	0.021	0.013	0.032
Area East									
2014/2015	0.011	0.006	0.017	0.002	0.000	0.004	0.000	0.000	0.842
2015/2016	0.021	0.017	0.025	0.018	0.015	0.021	0.019	0.012	0.030
2016/2017	0.043	0.033	0.054	0.035	0.029	0.043	0.034	0.025	0.044
2017/2018	0.040	0.029	0.053	0.041	0.033	0.050	0.061	0.048	0.075
2018/2019	0.007	0.003	0.014	0.027	0.020	0.036	0.059	0.046	0.074
Area West									
2014/2015	0.000	0.000	0.018	0.000	0.000	0.009	0.000	0.000	0.708
2015/2016	0.028	0.019	0.039	0.013	0.008	0.019	0.024	0.008	0.056
2016/2017	0.015	0.010	0.024	0.012	0.009	0.016	0.015	0.009	0.022
2017/2018	0.016	0.009	0.027	0.022	0.018	0.026	0.025	0.019	0.033
2018/2019	0.039	0.025	0.059	0.033	0.028	0.038	0.036	0.028	0.046

TABLE A4 Prevalence estimates of wild boar with an ASFV PCR-positive and a seropositive test results, stratified by region, hunting season and age class

	<1 year			1–2 years			>2 years		
	Prevalence	Lower 95% CI	Upper 95% CI	Prevalence	Lower 95% CI	Upper 95% CI	Prevalence	Lower 95% CI	Upper 95% CI
Latgale									
2014/2015	0.007	0.003	0.014	0.001	0.000	0.003	0.000	0.000	0.975
2015/2016	0.010	0.006	0.016	0.004	0.002	0.008	0.000	0.000	0.009
2016/2017	0.011	0.006	0.020	0.004	0.001	0.010	0.001	0.000	0.008
2017/2018	0.008	0.003	0.020	0.009	0.004	0.017	0.007	0.002	0.016
2018/2019	0.019	0.009	0.034	0.006	0.002	0.014	0.006	0.001	0.017
Vidzeme									
2014/2015	0.002	0.000	0.010	0.000	0.000	0.004	0.000	0.000	0.975
2015/2016	0.016	0.012	0.021	0.004	0.003	0.007	0.000	0.000	0.007
2016/2017	0.014	0.006	0.026	0.007	0.003	0.012	0.004	0.001	0.011
2017/2018	0.014	0.006	0.029	0.012	0.007	0.020	0.005	0.001	0.015
2018/2019	0.000	0.000	0.008	0.001	0.000	0.006	0.000	0.000	0.006
Pieriga									
2014/2015	0.000	0.000	0.066	0.000	0.000	0.023	0.000	0.000	0.975
2015/2016	0.006	0.001	0.018	0.002	0.000	0.009	0.008	0.000	0.045
2016/2017	0.017	0.010	0.028	0.008	0.004	0.013	0.002	0.000	0.009
2017/2018	0.036	0.021	0.059	0.007	0.003	0.011	0.004	0.001	0.012
2018/2019	0.035	0.013	0.075	0.008	0.003	0.017	0.000	0.000	0.009
Zemgale									
2014/2015	0.000	0.000	0.033	0.000	0.000	0.019	0.000	0.000	0.975
2015/2016	0.003	0.000	0.010	0.002	0.000	0.006	0.000	0.000	0.043
2016/2017	0.011	0.003	0.027	0.004	0.001	0.009	0.000	0.000	0.009
2017/2018	0.025	0.009	0.055	0.007	0.004	0.013	0.006	0.001	0.017
2018/2019	0.009	0.000	0.049	0.009	0.004	0.018	0.004	0.000	0.020
Kurzeme									
2014/2015	0.000	0.000	0.079	0.000	0.000	0.049	0.000	0.000	0.975
2015/2016	0.000	0.000	0.975	0.000	0.000	0.708	0.000	0.000	0.975
2016/2017	0.000	0.000	0.033	0.004	0.001	0.013	0.000	0.000	0.014
2017/2018	0.000	0.000	0.018	0.011	0.007	0.016	0.004	0.001	0.011
2018/2019	0.007	0.001	0.026	0.008	0.005	0.012	0.004	0.001	0.011
Area East									
2014/2015	0.006	0.003	0.010	0.000	0.000	0.002	0.000	0.000	0.842
2015/2016	0.014	0.011	0.018	0.004	0.003	0.006	0.000	0.000	0.004
2016/2017	0.012	0.007	0.019	0.006	0.003	0.009	0.003	0.001	0.007
2017/2018	0.011	0.006	0.019	0.011	0.007	0.016	0.006	0.003	0.012
2018/2019	0.010	0.005	0.018	0.003	0.001	0.008	0.003	0.001	0.008
Area West									
2014/2015	0.000	0.000	0.018	0.000	0.000	0.009	0.000	0.000	0.708
2015/2016	0.004	0.001	0.010	0.002	0.001	0.005	0.005	0.000	0.027
2016/2017	0.014	0.008	0.022	0.006	0.004	0.009	0.001	0.000	0.005
2017/2018	0.025	0.015	0.037	0.008	0.006	0.011	0.004	0.002	0.008
2018/2019	0.016	0.007	0.030	0.008	0.006	0.011	0.003	0.001	0.007

TABLE A5 Prevalence estimates of wild boar with an ASF PCR-positive and a seronegative test results, stratified by region, hunting season and age class

	<1 year			1–2 years			>2 years		
	Prevalence	Lower 95% CI	Upper 95% CI	Prevalence	Lower 95% CI	Upper 95% CI	Prevalence	Lower 95% CI	Upper 95% CI
Latgale									
2014/2015	0.009	0.004	0.016	0.005	0.003	0.010	0.000	0.000	0.975
2015/2016	0.017	0.011	0.025	0.007	0.004	0.011	0.005	0.001	0.017
2016/2017	0.011	0.006	0.020	0.008	0.003	0.014	0.003	0.000	0.010
2017/2018	0.039	0.025	0.058	0.013	0.007	0.022	0.010	0.004	0.020
2018/2019	0.004	0.000	0.013	0.010	0.004	0.019	0.008	0.002	0.020
Vidzeme									
2014/2015	0.007	0.002	0.019	0.002	0.000	0.009	0.000	0.000	0.975
2015/2016	0.024	0.019	0.031	0.012	0.009	0.016	0.005	0.001	0.016
2016/2017	0.020	0.011	0.035	0.018	0.012	0.025	0.007	0.003	0.016
2017/2018	0.010	0.003	0.024	0.010	0.005	0.017	0.003	0.000	0.012
2018/2019	0.000	0.000	0.008	0.000	0.000	0.004	0.000	0.000	0.006
Pieriga									
2014/2015	0.000	0.000	0.066	0.000	0.000	0.023	0.000	0.000	0.975
2015/2016	0.035	0.020	0.055	0.018	0.010	0.029	0.016	0.002	0.058
2016/2017	0.017	0.010	0.028	0.020	0.014	0.028	0.009	0.004	0.019
2017/2018	0.036	0.021	0.059	0.016	0.011	0.023	0.011	0.005	0.022
2018/2019	0.006	0.000	0.032	0.021	0.013	0.034	0.003	0.000	0.014
Zemgale									
2014/2015	0.000	0.000	0.033	0.000	0.000	0.019	0.000	0.000	0.975
2015/2016	0.005	0.001	0.014	0.003	0.001	0.009	0.012	0.000	0.066
2016/2017	0.008	0.002	0.023	0.012	0.006	0.020	0.000	0.000	0.009
2017/2018	0.021	0.007	0.049	0.016	0.011	0.023	0.016	0.007	0.032
2018/2019	0.000	0.000	0.032	0.023	0.014	0.036	0.004	0.000	0.020
Kurzeme									
2014/2015	0.000	0.000	0.079	0.000	0.000	0.049	0.000	0.000	0.975
2015/2016	0.000	0.000	0.975	0.000	0.000	0.708	0.000	0.000	0.975
2016/2017	0.018	0.002	0.064	0.029	0.018	0.045	0.034	0.016	0.064
2017/2018	0.014	0.003	0.042	0.022	0.016	0.029	0.013	0.006	0.023
2018/2019	0.011	0.002	0.031	0.015	0.011	0.020	0.017	0.009	0.027
Area East									
2014/2015	0.008	0.005	0.014	0.004	0.002	0.008	0.000	0.000	0.842
2015/2016	0.022	0.018	0.027	0.010	0.008	0.013	0.005	0.002	0.012
2016/2017	0.014	0.009	0.022	0.014	0.010	0.019	0.005	0.002	0.010
2017/2018	0.026	0.017	0.037	0.011	0.007	0.016	0.007	0.003	0.013
2018/2019	0.002	0.000	0.007	0.005	0.002	0.009	0.004	0.001	0.009
Area West									
2014/2015	0.000	0.000	0.018	0.000	0.000	0.009	0.000	0.000	0.708
2015/2016	0.017	0.011	0.026	0.009	0.006	0.015	0.015	0.003	0.042
2016/2017	0.015	0.009	0.023	0.019	0.015	0.025	0.011	0.007	0.018
2017/2018	0.027	0.017	0.040	0.018	0.015	0.022	0.013	0.008	0.019
2018/2019	0.007	0.002	0.018	0.018	0.014	0.022	0.011	0.007	0.017

TABLE A6 Prevalence estimates of wild boar with an ASFV PCR-positive results, irrespective of the serological test result, stratified by region, hunting season and origin of carcass

	A			P		
	Prevalence	Lower 95% CI	Upper 95% CI	Prevalence	Lower 95% CI	Upper 95% CI
Latgale						
2014/2015	0.011	0.007	0.015	0.684	0.567	0.786
2015/2016	0.016	0.013	0.021	0.861	0.781	0.920
2016/2017	0.013	0.009	0.018	0.800	0.687	0.886
2017/2018	0.027	0.021	0.035	0.745	0.610	0.853
2018/2019	0.017	0.012	0.024	0.300	0.067	0.652
Vidzeme						
2014/2015	0.008	0.005	0.013	0.752	0.688	0.810
2015/2016	0.024	0.021	0.028	0.801	0.760	0.838
2016/2017	0.023	0.018	0.028	0.855	0.794	0.904
2017/2018	0.019	0.014	0.025	0.778	0.655	0.873
2018/2019	0.001	0.000	0.003	0.400	0.053	0.853
Pieriga						
2014/2015	0.000	0.000	0.015	0.211	0.061	0.456
2015/2016	0.027	0.020	0.037	0.652	0.546	0.749
2016/2017	0.026	0.021	0.032	0.746	0.673	0.809
2017/2018	0.028	0.022	0.035	0.706	0.629	0.774
2018/2019	0.023	0.016	0.033	0.341	0.201	0.506
Zemgale						
2014/2015	0.000	0.000	0.011	0.417	0.152	0.723
2015/2016	0.006	0.003	0.011	0.483	0.294	0.675
2016/2017	0.013	0.008	0.019	0.593	0.457	0.719
2017/2018	0.026	0.020	0.033	0.796	0.703	0.871
2018/2019	0.025	0.017	0.035	0.750	0.194	0.994
Kurzeme						
2014/2015	0.000	0.000	0.030	0.000	0.000	0.265
2015/2016	0.000	0.000	0.459	0.000	0.000	0.109
2016/2017	0.032	0.022	0.044	0.561	0.465	0.654
2017/2018	0.027	0.022	0.034	0.778	0.724	0.826
2018/2019	0.022	0.018	0.027	0.696	0.602	0.780
Area East						
2014/2015	0.010	0.007	0.013	0.734	0.678	0.785
2015/2016	0.021	0.019	0.024	0.813	0.777	0.845
2016/2017	0.018	0.015	0.022	0.840	0.787	0.883
2017/2018	0.023	0.019	0.028	0.763	0.676	0.836
2018/2019	0.009	0.006	0.012	0.333	0.118	0.616
Area West						
2014/2015	0.000	0.000	0.005	0.209	0.100	0.360
2015/2016	0.015	0.011	0.020	0.484	0.402	0.566
2016/2017	0.023	0.019	0.027	0.658	0.605	0.708
2017/2018	0.027	0.024	0.031	0.759	0.721	0.795
2018/2019	0.023	0.019	0.027	0.605	0.524	0.682

Note: Column A contains the numbers of samples obtained by active surveillance (hunting of apparently healthy wild boar) and P by passive surveillance (found dead, shot sick or road traffic accident).

III

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Hunters' view on the control of African swine fever in wild boar. A participatory study in Latvia

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ABSTRACT

African swine fever (ASF) has massively spread in recent years and threatens the global pig industry. ASF has been present in Latvia since 2014. Hunters play a major role in the implementation of measures to control ASF and in passive disease surveillance. The probability to detect an ASF-positive wild boar is much higher in animals found dead than in hunted animals. Thus, the willingness and the motivation of hunters to support passive surveillance is of utmost importance. Using participatory methods, this study aimed to assess the acceptability of control measures for ASF in wild boar among hunters. In addition, new approaches to increase hunters' motivation to report wild boar found dead were investigated.

A total of ten focus group discussions with hunters from different regions in Latvia were conducted. To assess the quantity and quality of contacts between hunters and stakeholders involved in the control of ASF, relation diagrams were used. Using ranking tools, the trust of the participants in stakeholders to implement control measures successfully was evaluated. Defined control measures were presented to the hunters and their acceptability investigated. An impact diagram and a list of defined motivation options for passive surveillance were offered to identify new ways to increase the willingness of hunters to support passive surveillance actively.

A satisfactory and regular relationship was identified between the hunters, the Food and Veterinary Service (FVS) and the State Forest Service (SFS). The hunters' trust in these authorities was high. Although there is no vaccine against ASF, hunters were convinced of the potential of vaccination in controlling ASF. However, building fences was considered as useless and ineffective. To increase the willingness of hunters to support passive surveillance, reducing the infection pressure in the forests was regarded as most motivating. Furthermore, hunters would appreciate a decrease in their costs and workload.

The study provides new insight into the concerns and experiences of hunters. Including their views and expectations in the further design and implementation of control and surveillance activities may help to improve current efforts to control ASF in wild boar populations. Although representing the perceptions of Latvian hunters, the main conclusions may be adaptable to adjust ASF control and surveillance in other countries.

1. Introduction

African swine fever (ASF) was introduced into Georgia in 2007 (Sanchez-Vizcaino et al., 2013). With the exception of Sardinia, where the disease has been endemic since 1978, this introduction was the first one in Europe since the eradication of ASF in 1995 (Sanchez-Cordon et al., 2018; Cwynar et al., 2019). Since then, ASF has spread widely. In 2014, the disease reached Poland and Lithuania. Latvia was the third member state of the European Union (EU), where ASF was introduced in June 2014. The first ASF cases emerged in wild boar in the eastern part of the country (Oļševskis et al., 2016; Schulz et al., 2019). Over time, the disease spread towards the West, so that most of the country has now

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been affected by ASF.

Infected wild boar constitute a major threat for domestic pig holdings. Controlling ASF in these animals is much more difficult than in domestic pigs, but it is of vital importance for the pig industry (Depner et al., 2016; European Food Safety Authority, 2018; Schulz et al., 2019). In Latvia, several control measures have been applied for defined periods. Monetary incentives were paid to hunters for shooting wild boar, particularly for animals older than one year and for female wild boar. Driven hunts and baiting were restricted. In addition, the collection and safe disposal of wild boar carcasses was enforced (Schulz et al., 2019). Schulz et al. (2019) found that the implemented control measures had little effect on the prevalence of ASF virus (ASFV)-positive wild boar in the short term. However, more recent findings indicate a decline in the incidence of ASFV-positive animals, which may suggest that the control measures could have had an impact on the course of ASF in wild boar in the long term (Oļševskis et al., 2020).

Passive surveillance, i.e. the reporting or sampling of wild boar found dead is not only an important requirement for control measures to hinder the spread of the virus, but also the most important surveillance tool for the early detection of ASF (Oļševskis et al., 2016; Smietanka et al., 2016; European Food Safety Authority et al., 2017; Nurmoja et al., 2017). The probability to detect an ASFV-positive wild boar among animals found dead is significantly higher as compared to hunted wild boar (Nurmoja et al., 2017; European Food Safety Authority, 2018, 2019; Schulz et al., 2019).

Neither ASF control measures nor passive surveillance in wild boar can be effectively implemented without the support of hunters. Hunters play a major role in wildlife management and therefore also in the implementation of measures to control diseases in the wild boar population (Schulz et al., 2016; Quiros-Fernandez et al., 2017). However, in Latvia, hunting is just a hobby and any associated activities occur on a voluntary basis. Accordingly, hunters' willingness to support control measures and passive surveillance for ASF in wild boar is vital.

Participatory methods can help to explore the rationales, experiences and concerns of key players concerning the design and implementation of control measures and passive surveillance (Catley et al., 2012; Calba et al., 2016; Schulz et al., 2016; Allepuz et al., 2017). For a long time, participatory methods were almost exclusively used in settings in developing countries. However, by recognising the advantages of including these methods into conventional epidemiological research, the application of these methods, also in developed countries, increased recently (Calba et al., 2015, 2016; Duval et al., 2016; Schulz et al., 2016). In contrast to traditional epidemiology, participatory methods involve the affected persons or groups in defining relevant problems and in the process of finding solutions that are readily applicable and satisfy all affected parties (Catley et al., 2012; Mariner et al., 2014). Various tools are used to ease communication and to understand the rationales of the persons and stakeholders involved. The results of the studies can be used to improve surveillance activities and disease control. The acceptability of certain measures or activities is defined as the willingness of key players to participate actively and support activities (Meynard et al., 2008). Often, acceptability is assessed by applying participatory methods (Bronner et al., 2014; McKerr et al., 2015).

In the present study, we used participatory methods to assess the acceptability of control measures for ASF in wild boar among Latvian hunters. Furthermore, we investigated the willingness of hunters to support passive surveillance in order to identify the best options for motivating hunters to increase passive surveillance. The results may help to improve ASF control measures and to increase the effectiveness of passive surveillance.

2. Materials & methods

2.1. Focus group discussions

The method of focus group discussions was chosen as a suitable method for data collection to allow for expression of a variety of views and perceptions of hunters. This was combined with visualization, ranking and scoring methods to gather numerical data. All participating hunters were informed about the aims of the study, the principles of participatory epidemiology and logistic details of the meetings. After anonymity had been assured, all participating hunters agreed that the meetings could be recorded and the results published. The discussions were held and recorded (by a typist) in Latvian. For further analyses, the transcript was translated into English by the professional translator company 'Skrivanek Baltic' (https://skrivanek.lv/en/).

The discussions were divided into two parts. First, the acceptance of ASF control measures was addressed. In the second part, impediments or motivation options were identified that might influence hunters' support for passive surveillance.

The participatory methods used in the present study were adapted from Calba et al. (2015) and Schulz et al. (2016). They were also applied in the study of Urner et al. (2020).

All meetings were guided by the same facilitator. The facilitator was trained in the applied methodology and was advised to ensure similar participation of all hunters in the discussions. The facilitator was a female employee of the Latvian Food and Veterinary Service who had no prior contact with hunters, ASF and its monitoring before the meetings. Results of the participatory methods were analysed in a semi-quantitative fashion and the qualitative results of the recorded discussions were included descriptively.

2.2. Recruiting hunters

For the focus group discussions (FGD), three to six hunters per meeting were recruited between April and July 2019. In close cooperation with the two largest Latvian hunting organisations ("Latvian Hunter's association" and "Latvian Hunter's Union"), hunters from five (Kurzeme, Latgale, Pierīga, Vidzeme and Zemgale) out of six administrative regions of Latvia were recruited to cover the whole territory of Latvia (Fig. 1). Therefore, in each region, two FGD were conducted. The hunting organisations provided a list of potential contact persons on a regional or local level, mostly leaders of regional or local hunting clubs. The leading hunters were contacted by phone, invited to participate and asked to identify further hunters who might be willing to participate voluntarily in the study. The criterion for participation of the hunters was their willingness to participate. These hunters were then contacted and invited to the focus group discussions.

2.3. Assessment of control measures

A relation diagram was applied to assess hunters' satisfaction with the perceived network of stakeholders involved in controlling ASF. The hunters first listed stakeholders, whom they considered as relevant in the network of control measures. The quantity of contacts (from 'no contact' to 'daily contact') between the hunters and each listed stakeholder was assessed by arrows (Fig. 2). Each contact was classified as outgoing from the hunters reaching out to the stakeholder and vice versa. Within each focus discussion group, consensus had to be reached for each arrow. Subsequently, each hunter received three smileys, which were used to rate the quality of the contacts individually (Fig. 2). The individual rating could be seen by each of the participants. Hunters' trust in the stakeholders' performance in ASF control was assessed by 'proportional piling'.

For the process of proportional piling, the participants had to achieve consensus in their discussion and to attribute then 100 glass beans in proportion to their trust in the listed stakeholders to implement control measures successfully.

The listed control measures were presented to the participants for evaluation:

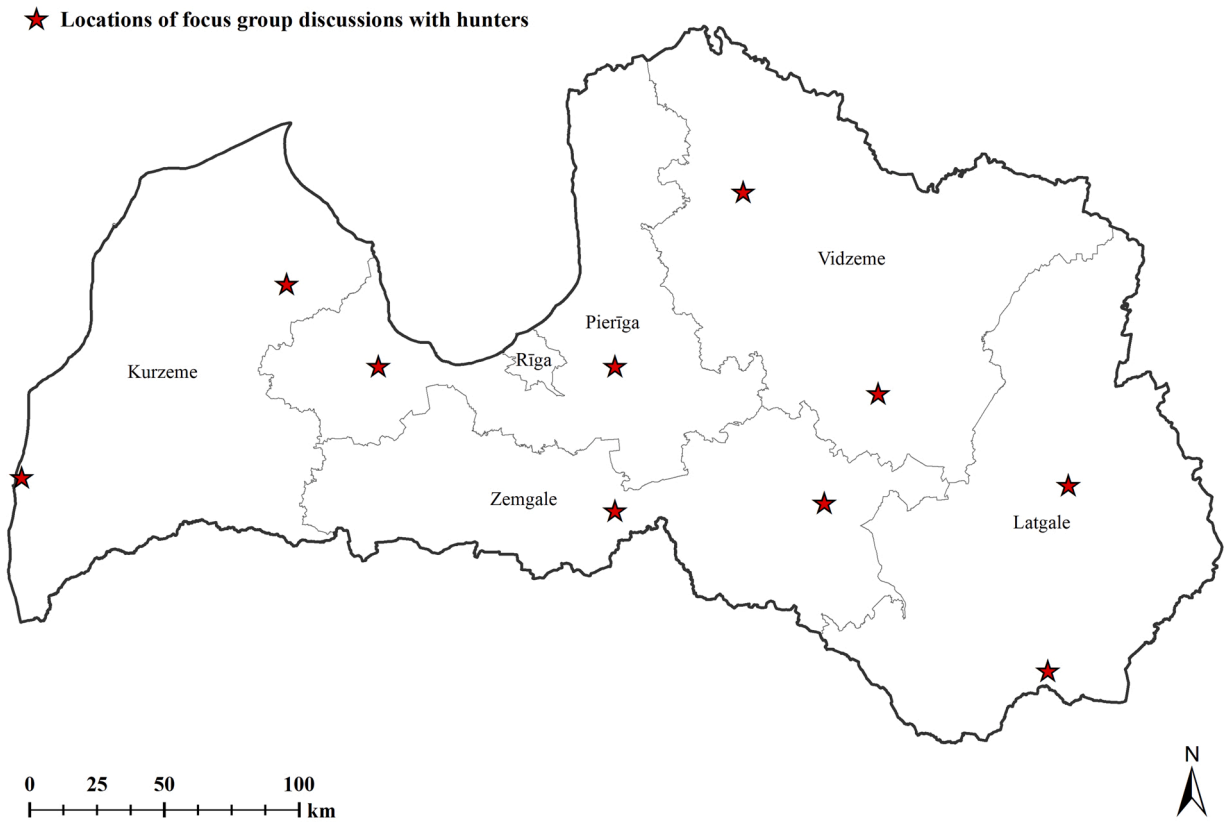

Fig. 1. Locations of the focus group discussions with hunters in five administrative regions in Latvia.

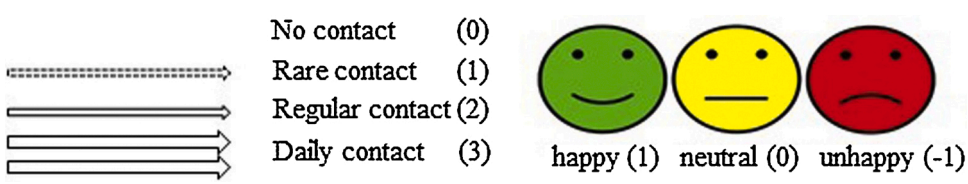

Fig. 2. Arrows, smileys and glass beans and the ranks assigned to them. The number of glass beans attributed to a stakeholder represented the proportion of trust in the respective stakeholder.

- Fencing
- Ban of hunting
- Including professionals for intensive hunting (police or army)
- Increased hunting of female wild boar (WB)
- Incentives for hunting
- Increased carcass search and removal

The hunters had the chance to add further control measures. Each hunter was requested to express his/her personal view on each individual control measure using smileys. To display the hunters' trust in the effectivity of the measures to control ASF, 'proportional piling' was applied.

2.4. Assessment of passive surveillance

An impact diagram was used to assess negative and positive consequences expected by hunters when detecting and reporting a wild boar found dead. After the participants had listed potential consequences, they were requested to reach consensus and attribute 100 glass beans proportionally to the perceived size of impact of the listed consequences. All consequences were thereby included in the same ranking process, irrespective of their character as presumed negative or positive consequences.

To assess the acceptability of possible motivation options to improve participation in passive surveillance, the following items were listed and the hunters asked to add further options:

- Increase of currently paid compensation
- Reduction of infection pressure in the wild boar population (by finding, sampling and removing carcasses)
- Only reporting dead wild boar without any further work for the hunter
- Detailed feedback on the health status of the detected wild boar from the relevant authority to the hunter

'Proportional piling' was used to assess the participants' trust in the listed options to motivate hunters to improve their support for passive surveillance.

2.5. Quantitative analyses

The average of contacts between hunters and stakeholders were calculated by assigning the appropriate rank to the respective arrows (Fig. 2). To determine the quality of contacts, i.e. the satisfaction with the quantity of cooperation with the rated stakeholders, ranks were assigned according to the numbers of smileys given (Fig. 2).The average

was calculated for each individual group and for all groups that had mentioned a particular stakeholder.

'Proportional piling' was applied and analysed with a weighted average. For example, the assessment of the trust in the listed control measures was calculated as follows: The average trust T_{CMi} was calculated taking the control measures CM_i i ∈ {1,…,28}, listed by all participants, into account. In the first step, the proportion of glass beans assigned to the control measures P_j was calculated by weighting the number of glass beans GB_{ij} allocated to the control measure CM_j from group G_j with j ∈ {1,…,10} in relation to Z_j^{CM}, the number of control measures CM listed by group G_j.

$$P_j = \frac{Z_j^{CM}}{\sum_{j=1}^{10} Z_j^{CM}}$$

The average trust T_{CMi} for all control measures was calculated with N_{CMi}, the number of groups G mentioning control measure CM_j,

$$T_{CM_i} = \frac{1}{N_{CM_i}} \cdot \sum_{j=1}^{10} P_j \cdot GB_{ij}$$

3. Results

3.1. Recruiting hunters

Between April and July 2019, ten focus group discussions with 50 participants in total, 49 men and one woman, were conducted across Latvia (Fig. 1). In each of the administrative regions of Latvia, two focus group discussions were held (Table 1). The estimated average age of the participants was 50 years.

3.2. Control measures

The participants named 27 stakeholders in total. All ten groups mentioned the Food and Veterinary Service (FVS), the State Forest Service (SFS) and the respective municipal administrations. Eight groups mentioned hunters, seven named the hunting organisations. Three to five groups mentioned the media, landowners, the Ministry of Agriculture (MoA), the "Latvia's State Forests" (a joint stock company), the State Police, scientists of the Institute of Food Safety, Animal Health and Environment "BIOR", farmers, the society and logging companies. Disposal companies were named twice. Each, the hunters' magazine, the Ministry of Interior, the laboratory, veterinarians, individual hunters, State Border Guards, Municipal Police, the European Commission, national media (TV & Radio), farmers' parliament, the State Environmental Service and animal protection organisations were mentioned once (Fig. 3). The participants expressed the highest trust in the proper implementation of control measures against ASF in wild boar by the FVS followed by hunters, hunting organisation and the SFS (Fig. 3).

The largest numbers of contacts of the participants (quantity) were with other hunters and stakeholders of the regular routine procedures, i.e. laboratory, FVS, SFS, hunting organisations and the municipal administrations. The hunters had little contact with the national research centre, veterinarians, the police, disposal companies and the MoA (Fig. 4). The quality of contact was higher for stakeholders with a large number of contacts than for stakeholders with a small number of contacts.

Analysis of the translated recordings of the focus discussion groups revealed that the hunters considered their co-operations with the FVS as positive. Feedback was regarded as sufficient and the employees of the FVS were mentioned to be solution-oriented and helpful. The SFS was also perceived as solution-oriented, but a lack of information and communication was reported. At the local level, there were only contacts with the municipal administrations and the police. The participants mentioned the companionable teamwork with other hunters and hunting organisations, based on their perception, that they were the 'real workers' in the control of ASF. The assumed important role of loggers and logging companies in the local spread of ASF was mentioned in connection with the perceived disinterest of these stakeholders in any ASF-related topic. The hunters believed that the focus of the Ministry of Interior, the MoA and BIOR, was exclusively on conducting office and desktop work, without taking the "whole picture" and the daily routines sufficiently into account. The hunters desired more communication with the authorities to have a chance to express their views and share their experience.

Vaccination was the most trusted measure to control ASF and received the highest value for satisfaction, followed by incentives for hunting, intensive hunting and biosecurity measures. Increased hunting of females received lower trust ratings and was not favoured by the participants. Fencing, involvement of police or army and the ban of hunting were the least-trusted control measures and received the lowest values for satisfaction (Fig. 5). Further control measures involved in the weighted average, which were mentioned only three times or less, were for example education of hunters on all ASF-related issues, various hunting methods, restriction of public access to areas with ASF-infected wild boar, poisoning and hunting of birds or small predators (Supplemental material Table 1).

In the discussion, covering hunters' costs that arise from their participation in the control measures during hunting was considered as an absolute requirement. Nevertheless, hunters who only hunt for money were considered as ethically dubious. Education and improved biosecurity to be implemented by everybody working in the forest were seen as beneficial for hunters, veterinarians and loggers in reducing the local spread of ASF. Increased hunting of females was regarded as an appropriate measure to reduce the size of the wild boar population, but not as trustworthy in controlling ASF. Moreover, it was disliked in its implementation, due to issues of hunting ethics. In particular, the risk of producing orphans during the farrowing season was seen as unacceptable. Hunting outside of the farrowing season was mentioned to be more satisfactory. Due to the perceived risk of intensified traffic in the forest, the hunters feared that the involvement of police or army and increased hunting of females might lead to spreading ASF rather than controlling it. Furthermore, the participants expressed concern that the police or the army might kill wild boar in an inappropriate or unethical way. They were perceived as unfamiliar with and untrained in hunting.

3.3. Passive surveillance

The hunters mentioned 31 consequences with respect to passive surveillance. Although several groups were not able to list any positive consequence of passive surveillance, reporting wild boar carcasses was a perceived positive consequence as it might help to control ASF. All other consequences of passive surveillance were regarded as negative (Fig. 6).

A self-inflicted duty and the interest of hunters to do everything in their power to control ASF were mentioned in the focus group discussions. Several problems were identified, including additional work, time

Table 1
Number of hunters per focus group discussion and administrative region of Latvia.

Administrative Region	Locations of focus group discussions	No of participating hunters
Pierīga	Ropazi	6
Pierīga	Tukums	4
Vidzeme	Valmiera	4
Vidzeme	Madona	4
Zemgale	Barbele	7
Zemgale	Jekabpils	6
Kurzeme	Talsi	5
Kurzeme	Liepaja	5
Latgale	Kraslava	5
Latgale	Rezekne	4

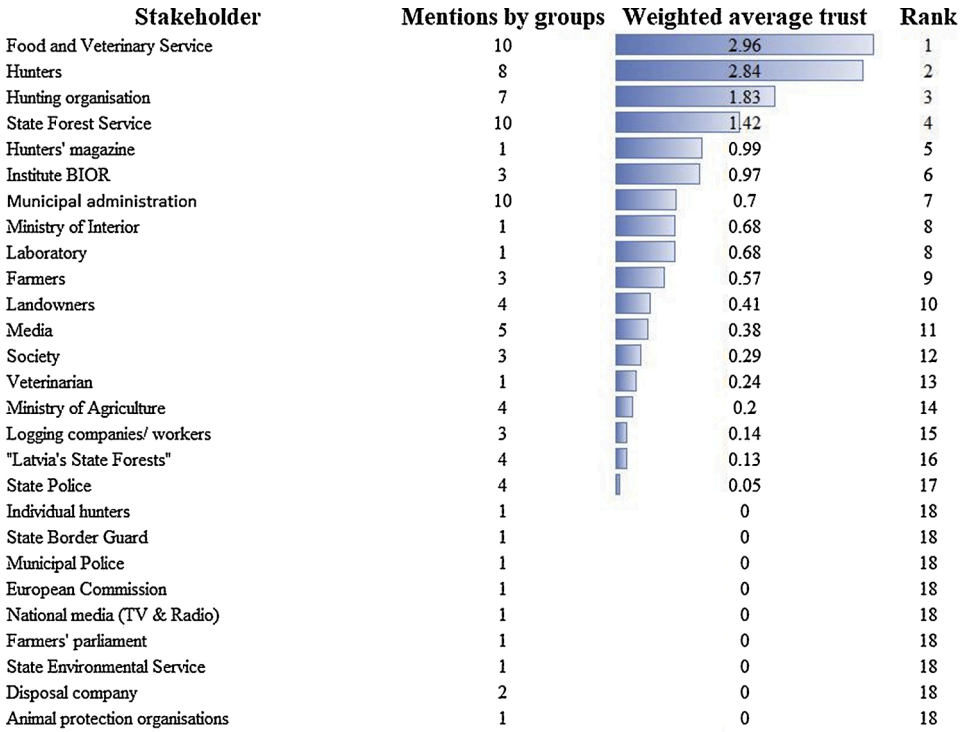

Fig. 3. Stakeholders listed by the ten focus discussion groups, ranked by hunters' trust in their proper implementation of control measures against ASF in wild boar.

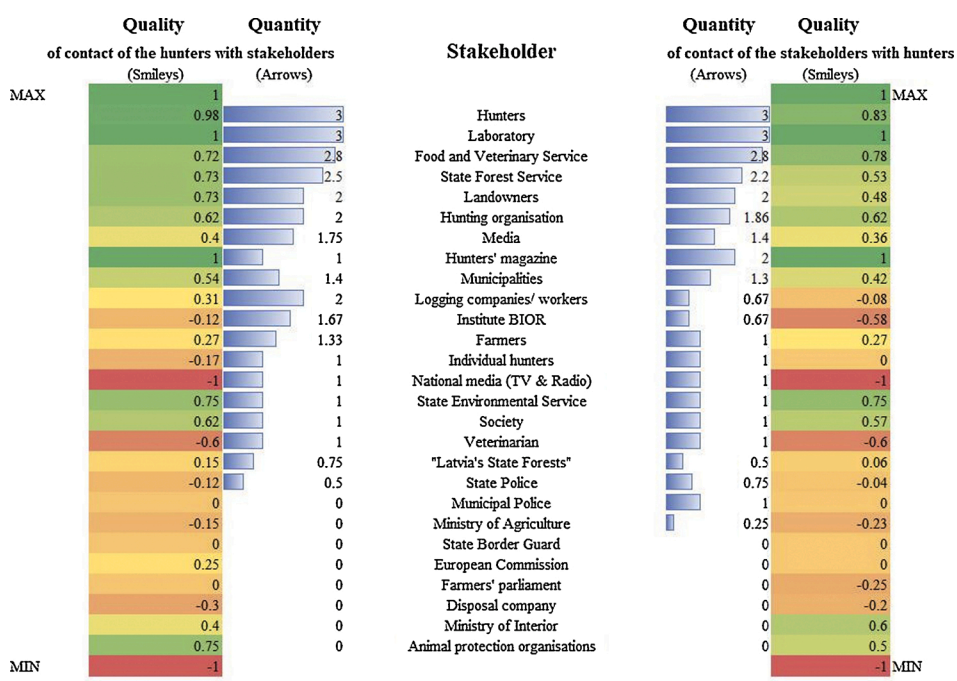

Fig. 4. Stakeholders mentioned in the focus discussion groups, ranked by the quantity of hunters' contacts with stakeholders (arrows) and the average quality of the contacts (smileys).

consumption and the costs of burying wild boar carcasses. The participants reported that they felt shocked when they were confronted with the duties imposed on them by national regulations and orders at the beginning of the ASF epidemic in wild boar. Missing information and the inability to bury wild boar carcasses in the forest without help or appropriate technical tools were mentioned. The participants perceived the current financial compensation as insufficient, as the time they were expected to spend on the respective activities (hunting, sampling and disposing carcasses etc.) could be used for "more rewarding" tasks, monetary and non-monetary (e.g. spending time with their families).

A potential reduction of the infection pressure within the wild boar population was perceived as the most motivational tool. This was followed by reducing the current workload to only reporting dead wild boar (i.e. transfer of further activities such as sampling and disposal of the carcasses to others), an increase in the currently paid compensation and detailed feedback on the health status of the detected wild boar

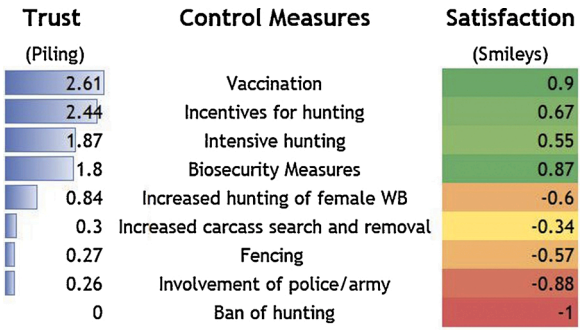

Fig. 5. Control measures mentioned by at least four of the ten focus discussion groups, ranked by trust in the perceived ability of the measures to control ASF efficiently and the hunters' satisfaction to implement the control measures.

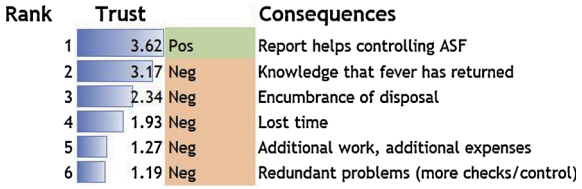

Fig. 6. Perceived consequences of passive surveillance mentioned by at least three focus discussion groups, ranked by the weighted average of glass beans allocated to the consequences in proportion to their perceived impact on the hunters.

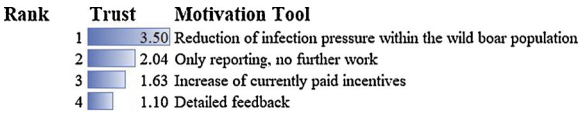

Fig. 7. Motivation tools, ranked by the weighted average of assigned glass beans in proportion to the perceived strength of motivational effect on hunters to participate in passive surveillance.

(Fig. 7). Further tools were included in the calculation of the weighted trust (Supplementary material Table 1).

In the discussions, the hunters explained that they regarded reducing the infection pressure in the wild boar population as their duty. Furthermore, difficulties in burying carcasses without help and fear of doing something in an incorrect way were mentioned. The participants expressed two ideas when discussing motivation tools: They proposed (i) a professional group for carcass removal, sampling and burial and (ii) programming a smart phone app that can be used by citizens or hunters to report the coordinates of found carcasses and to upload pictures. Moreover, the currently paid compensations were found to be too low and an optimised and faster financial flow of the monetary incentives from the authority to the hunters was seen as desirable.

4. Discussion

Participatory methods have so far not been intensively use in developed countries, despite their potential in involving key stakeholders in the design of disease surveillance and control programmes (Catley et al., 2012; Calba et al., 2014, 2015; Schulz et al., 2016). By choosing a participatory approach, stakeholders become involved and feel accepted as partners. Moreover, important information on the application of directives and orders in daily routines and topic-related expertise may become accessible.

However, participatory methods have their limitations as other knowledge-based approaches. One limitation of the present study was the lack of training of the facilitator in participatory methods. A one-day training focusing on this study was the only preparation that the facilitator received prior to the study. The training was supervised by the supervising author of the study, who received preliminary training at CIRAD (Centre de Coopération Internationale en Recherche Agronomique pour le Développement) (Schulz et al., 2016). The study questions and the implementation of focus group discussion was practiced with volunteers prior to the first implementation in the field. Therefore, some of the basic principles of participatory epidemiology may have remained unclear, which could have had an impact on the quality of the study. Particularly in focus group discussions, it is vital to include all participants. This helps to prevent dominant behaviour of individuals and thus to avoid losing the opinions of less dominant participants (Fischer et al., 2020). Furthermore, the used method of group discussions, in comparison to interviews (face to face or online by a questionnaire), might imply that participants can influence each other. While a dominant behaviour of individuals was controlled by the facilitator, there is the possibility that participants express opinions in the discussion or comment in specific ways to keep a particular social status or avoid to interfere with opinions of others. The moderation of the discussions, their recording and the translation of the transcripts into English involved the risk of information loss. To reduce translation bias, the transcript was checked by the Latvian colleagues and we double-checked all analyses with the facilitator.

In contrast to a similar study that we had conducted in Estonia (Urner et al., 2020), the facilitator was not an independent scientist, but a staff member of the FVS. She had neither been involved in work with hunters previously nor in ASF control management in wild boar. The lack of expert knowledge might have had a positive effect on the willingness of the participants to state their perceptions openly without any fear to disgrace themselves. On the other hand, the fact that the facilitator belonged to the FVS could have increased hunters' reluctance to express their real opinions loudly, particularly in case of a negative statement regarding the FVS. This potential bias may therefore be taken into account when the results are interpreted. However, a study with Estonian hunters, where an independent scientist acted as the facilitator, yielded similar results (Urner et al., 2020).

Hunters across five of the six administrative regions of Latvia were involved in the study to avoid clustered local opinions and experiences. The administrative region of the Latvian capital, Riga, was not included due to its urban character and relatively small area. The selection of participants often represents a limitation in social studies. This is also the case in the present study as the participating hunters may have been selected because they had been in contact with the authorities before the study or were particularly eager to express their opinion. Furthermore, the possibility of the leading hunters to contact only hunters, whom they knew and who might have similar opinions, cannot be excluded as a participation bias. Such a selection bias cannot be completely ruled out in these studies (Calba et al., 2015; Schulz et al., 2016). An obvious gender bias is illustrated by the fact that only a single woman could be recruited. The small number of participating women is likely to represent the small proportion of female hunters within the Latvian hunting community. Nevertheless, increasing the participation of female hunters would certainly be beneficial to expand the insight in the view of hunters.

Moreover, the representativeness of the study population (50 hunters) in relation to the total Latvian hunting community may be questioned. However, according to the observations of the facilitator, no new information was added by the hunters of the last focus groups to the already mentioned queries and perceptions. These observations resemble the systematically documented findings of Guest et al. (2006), in which saturation occurred within the first twelve interviews and basic elements were already present after six interviews. Finally, an age-related bias was present in this study. The estimated average age of the participants was 50 years, which represents the average age distribution in the Latvian hunting community. Nevertheless, an age-bias cannot be excluded.

We chose relation diagrams as a participatory method, assuming that a large quantity and a high quality of contacts between stakeholders in the network of control measures increases acceptance of measures to control ASF in wild boar. FVS, SFS and the hunters do most of the office- and fieldwork related to ASF control in wild boar. Therefore, the described combination of frequent and satisfactory contacts can be seen as beneficial for controlling ASF. As representatives of the hunting organisations are already invited to meetings where relevant information on the epidemiological situation and ASF control is shared, the perceived lack of communication between the SFS and the hunters may have been caused by missing communication between the representatives and every individual hunter.

Another suggestion of the participants was to post regular news on ASF in the media. This may also provide continuous information to the society as a whole, help to raise awareness and maintain it at a high level, if needed.

The contact with logging companies regarding the control of further spread of ASF was perceived as important by the participants. However, communication was regarded as difficult, highlighting the need for improvement, e.g. by sharing relevant information on ASF control measures also with logging companies.

Regarding the control measures assessed by the hunters, vaccination was often mentioned and perceived as the best solution. However, this control measure does unfortunately not exist at the moment as there is no effective vaccine against ASF available (EFSA, 2019). The mind-set of regarding vaccination as the only way to control ASF effectively could weaken the willingness of hunters to implement any of the currently available control measures. Therefore, further information on their effectiveness may lead to higher acceptance of all measures, except vaccination. Moreover, hunters need to be informed that vaccination against ASF is currently not an option. On several occasions, the participants mentioned the desire for continuous education of hunters regarding ASF and on the effects of control measures. Hunting and all other measures that support hunting were highly appreciated. To improve the acceptance of financial incentives, full compensation for the time and materials spent on ASF control need to be taken into consideration.

In addition to the presence of loggers, veterinarians, citizens and hunters in the forest, the participating hunters perceived the possible involvement of the army and the police as a serious biosecurity problem, also because it was expected that intensified carcass search supported by these forces may lead to increased traffic. Implementing educational trainings and discussions on biosecurity during hunting, logging, transportation and intensified carcass search could lead to a better understanding and to problem-oriented solutions that are supported by hunters, veterinarians and loggers.

Modification of control measures regarded as unethical (e.g. hunting of sows or hunting with perceived untrained stakeholders) could also lead to a better acceptance of these measures. The participants suggested limiting the increased hunt of sows to months outside the farrowing season. The perception that involving the army or the police might lead to unethical "killing" of wild boar could be changed by giving hunters a leading role in educating external forces and by hunting jointly.

Fencing was seen as a waste of money and time, because it was perceived as ineffective. Moreover, it was pointed out that fences represent obstacles for all wild animals. Therefore, it seems difficult to overcome these concerns, even if fencing is limited to small areas, if natural borders are used to avoid fences and if fences are constructed in such a way that the effect on non-target species is minimized (height, mesh size etc.). It should be noted that the effectiveness of fences is also controversially disputed in the scientific community (Jori et al., 2020). As poisoning wild boar was only mentioned as a potential control measure by two groups (and highly disliked), this measure may not be appropriate. Moreover, poisoning wild boar is unlikely to be accepted by the general public (Jori et al., 2020).

Passive surveillance in combination with carcass disposal is regarded as one of the most effective measures for controlling ASF in wild boar (Nurmoja et al., 2017; European Food Safety Authority, 2018, 2019; Schulz et al., 2019). Therefore, a high level of acceptance of passive surveillance by hunters, the key stakeholder, is of utmost importance to reduce the risk of ASF spread. The perceived consequences for hunters finding a dead wild boar were analysed under the assumption that knowing the consequences might help to adjust them and thus to increase the motivation of hunters to support passive surveillance.

Similar to the results reported by Calba et al. (2015) and Schulz et al. (2016), most Latvian hunters found it difficult to list any positive consequences, when detecting a dead wild boar. However, the existing commitment of the Latvian hunters to contribute to ASF control was demonstrated by their motivation to reduce the infection pressure within the wild boar population. Therefore, they were willing to help controlling ASF by finding and reporting dead wild boar, although they regarded the consequences as negative (Fig. 6).

The second most important consequence of finding and reporting a wild boar carcass was mentioned along with the comment that this meant that 'the disease has returned'. This illustrates the intrinsic interest of the participating hunters to control ASF. This motivation might originate from the perception of the hunters' duty and the often-stated importance of managing the wild boar population in an ethically acceptable way. To encourage hunters in participating in passive surveillance, the perceived negative consequences should at least be mitigated. The second most trusted tool to motivate hunters to participate in passive surveillance, i.e. only reporting wild boar carcasses without any obligation of sampling or disposal, was complemented by the participants' ideas to programme a smart phone app for reporting and to involve external forces in the search for wild boar carcasses. With respect to a reporting app, it should be noted that such a tool already exists in Germany (https://tierfund-kataster.de/tfk/tfk_erfassung.php).

To increase the acceptance of the involvement of groups like the army or logging companies, clear rules should be set up first, followed by information and biosecurity workshops. To reduce the workload for hunters, a professional group for carcass removal, sampling and burial could be implemented. In this regard, the participants suggested a proportional distribution of financial incentives among the involved stakeholders, depending on the level of their involvement. If hunters remain the stakeholder with the largest number of duties, it will be advisable to increase incentives for them. Although the Latvian hunters were largely satisfied with feedback and communication by the authorities in the country, the motivation tool of detailed feedback may be a relevant issue in other regions that should not be neglected.

5. Conclusions

The results of this study show hunters' views on aspects of ASF control and passive surveillance for the disease. The findings demonstrate a willingness of Latvian hunters to cooperate with the authorities in the control of ASF that may help to ensure the success of the measures. The results presented here offer the chance to include the hunters' views in the control of ASF in wild boar and to improve the measures by taking their acceptability into account. Successful control of ASF in wild boar seems only feasible with the active support of hunters for measures that are acceptable to them.

Ethics approval and consent to participate

All hunters participated voluntarily in the group discussions and were informed about the objectives of the study. They approved the anonymous publication of the results. In consultation with the Food and Veterinary Service formal consent or ethics approval was not required for this study, as it included neither clinical trials in humans, for which ethical approval might have been required, nor animal experiments.

Declaration of Competing Interest

All authors declare that they have no conflicts of interest relevant to this paper.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.prevetmed.2020.105229.

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