

Analysis of Vaccination Intervals

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Objective

The objective of this document is to analyze the durations related to vaccination protocols for meat and fatty duck production chains, with a view to integrating them into the ‘vaccination.R’ model.

Meat Duck Sector

```
# Load the CSV file containing vaccination data for meat ducks
Vacc_Chair=read.delim("data_vacc_IAHP_chair.csv",header = TRUE,sep=";",
                      colClasses=c(SIRET="character",INSEE="character"))

# Count the number of flocks without any vaccination (missing Age_V1)
nb_nonVacc=sum(is.na(Vacc_Chair$Age_V1))    ### 285
# Count the number of flocks with only the first vaccination (V1)
nb_V1_Unique=sum(!is.na(Vacc_Chair$Age_V1) & is.na(Vacc_Chair$Age_V2))    ### 164
# Count the number of flocks where V1 date equals V2 date (possible anomaly)
nb_V1_is_V2=sum(Vacc_Chair$Age_V1==Vacc_Chair$Age_V2,na.rm = T)    ### 5

# Clean data: remove flocks without V1, with only V1, or where V1 equals V2
Cleaned_Vacc_Chair=Vacc_Chair[which(!(is.na(Vacc_Chair$Age_V1)) &
                                     !(is.na(Vacc_Chair$Age_V1) & is.na(Vacc_Chair$Age_V2)) &
                                     !(Vacc_Chair$Age_V1==Vacc_Chair$Age_V2)),]
```

Number of flocks without vaccination : 285

Number of flocks with only V1 : 164

Number of flocks with V1=V2 : 5

Duration analysis

```
# Convert date columns to R Date format
Vacc_Chair$Date_sortie=as.Date(Vacc_Chair$Date_sortie,format="%d/%m/%Y")
# Convert date columns to R Date format
Vacc_Chair$Date_MEP=as.Date(Vacc_Chair$Date_MEP,format="%d/%m/%Y")
# Compute the total duration of the flock (from placement to exit)
Vacc_Chair$DureeLot=Vacc_Chair$Date_sortie -Vacc_Chair$Date_MEP

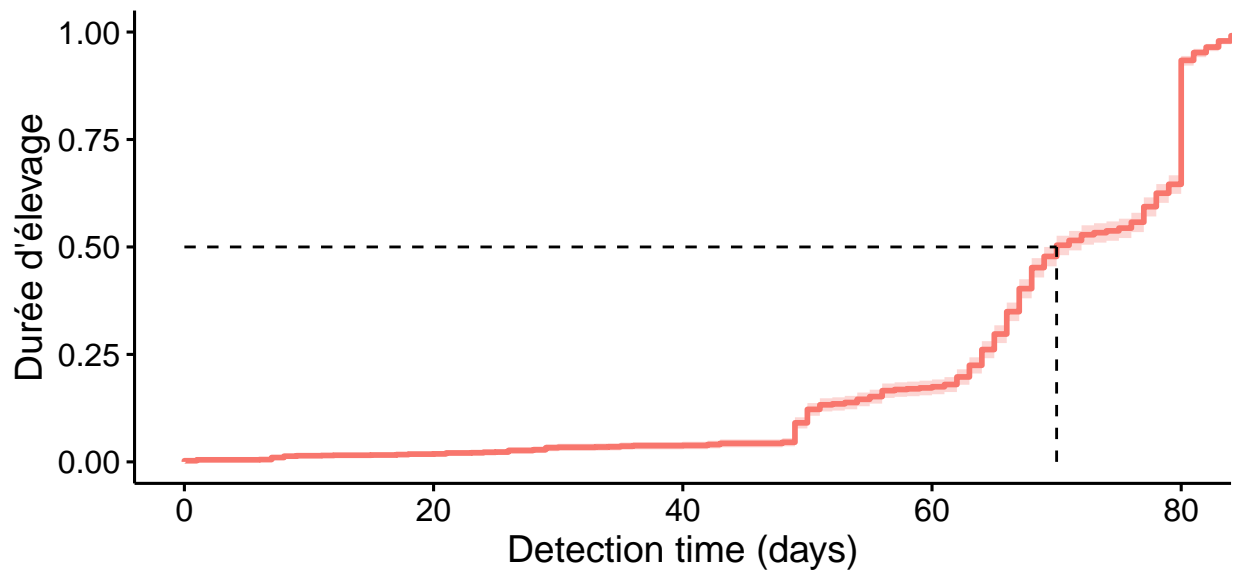
# Compute the total duration of the flock (from placement to exit)
S=Surv(Vacc_Chair$DureeLot,! (Vacc_Chair$DureeLot<0))
# Create a survival object for duration analysis
survPlot<-ggsurvplot(survfit(Surv(DureeLot,! (DureeLot<0))~1,
```

```

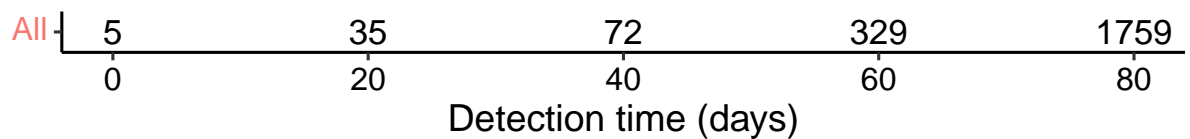
        data=Vacc_Chair), fun="event",
Vacc_Chair,
cumevents=TRUE, #risk.table = "nrisk_cumevents",
title=paste("Distribution des durées d\'élevage"),
legend.title="", legend="none", xlab="Detection time (days)",
ylab="Durée d\'élevage",
surv.median.line = "hv" #ncensor.plot=TRUE,
)
survPlot

```

Distribution des durées d'élevage



Cumulative number of events



```

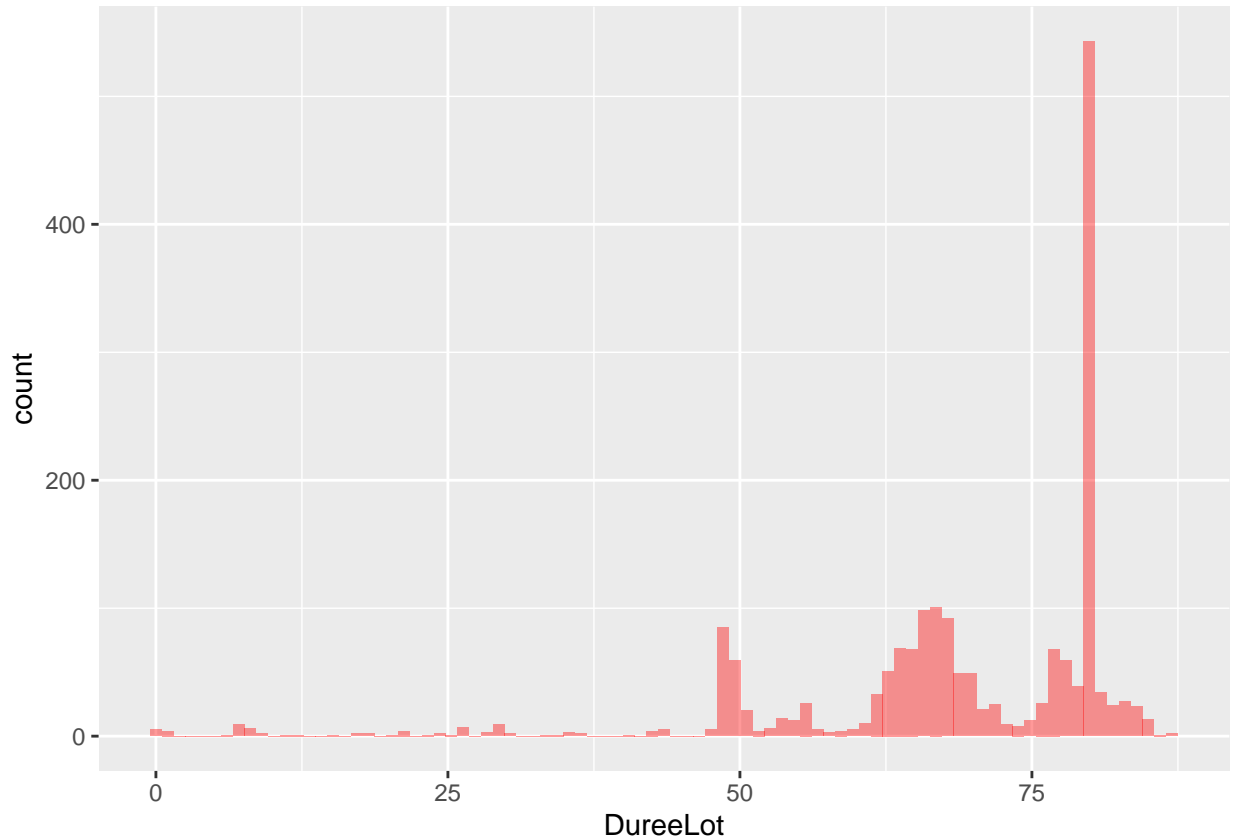
ggplot(data=Vacc_Chair, aes(x=DureeLot)) +
geom_histogram(
# Compute the total duration of the flock (from placement to exit)
bins = as.numeric(range(Vacc_Chair$DureeLot)[2]),
fill = "red",
alpha = 0.4
)

```

```

## Don't know how to automatically pick scale for object of type <difftime>.
## Defaulting to continuous.

```



```
#Distribution cumulée des probabilité de départ à l'abattoir en fonction de l'âge.
# Compute the total duration of the flock (from placement to exit)
tmp=cumsum(prop.table(table(Vacc_Chair$DureeLot)))
Sale=data.frame(Age=as.numeric(names(tmp)),proba=as.numeric(tmp))
```

Flock introductions

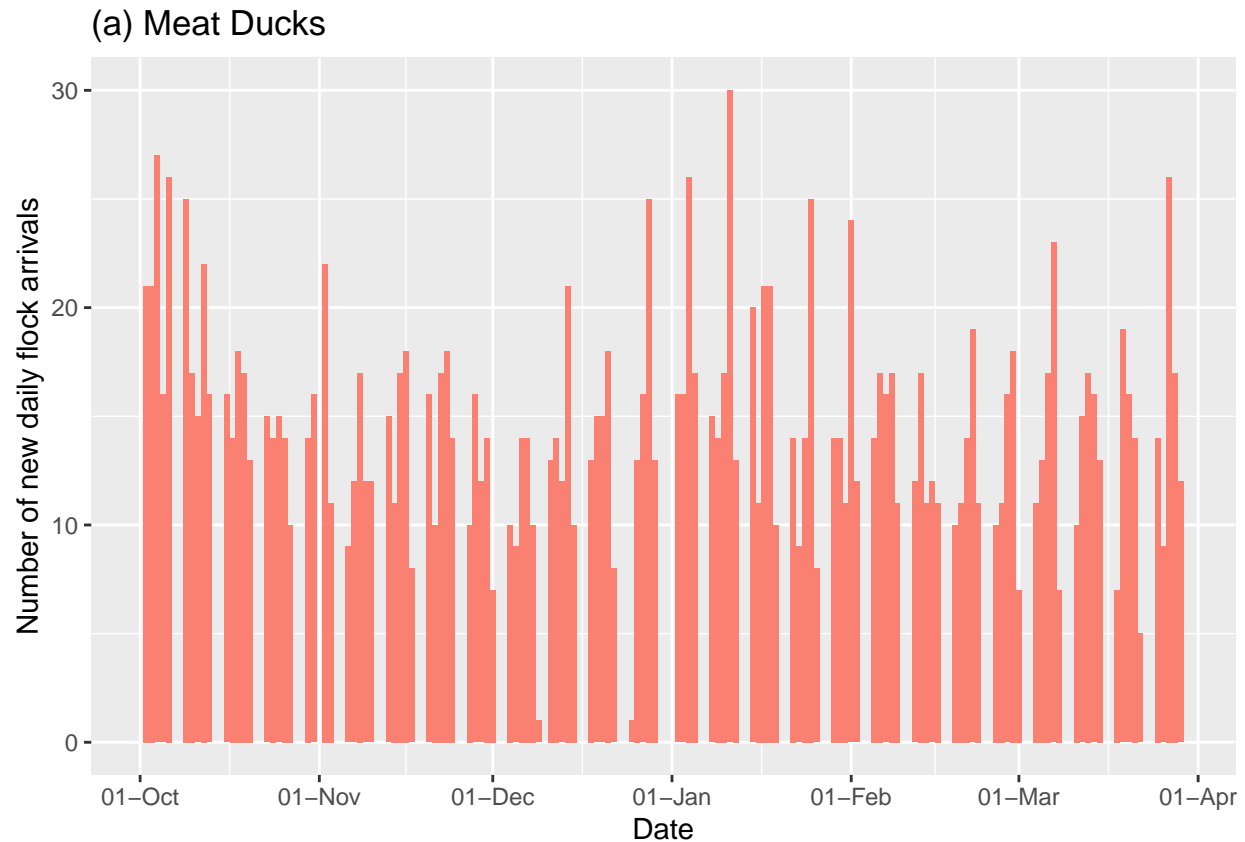
The MEP database defined below records the daily number of flocks placed during the study period

```
# Analysis of daily placement data
# Convert date columns to R Date format
data.frame(day=as.numeric(as.Date(names(table(Vacc_Chair$Date_MEP)))) - 19631,
           nintro=as.numeric(table(Vacc_Chair$Date_MEP)))->MEP

#FGraph associé à MEP
plot_MEP_Chair <- ggplot(data=Vacc_Chair,aes(x=Date_MEP))+
  geom_histogram(stat="count",
    bins = 163,
    fill = "salmon") +
  xlab("Date") +
  ylab("Number of new daily flock arrivals")+
  ggtitle("(a) Meat Ducks") +
  scale_x_date(date_breaks = "1 month", date_labels = "%d-%b")
```

```
## Warning in geom_histogram(stat = "count", bins = 163, fill = "salmon"):
## Ignoring unknown parameters: `binwidth`, `bins`, and `pad`
```

```
plot_MEP_Chair
```



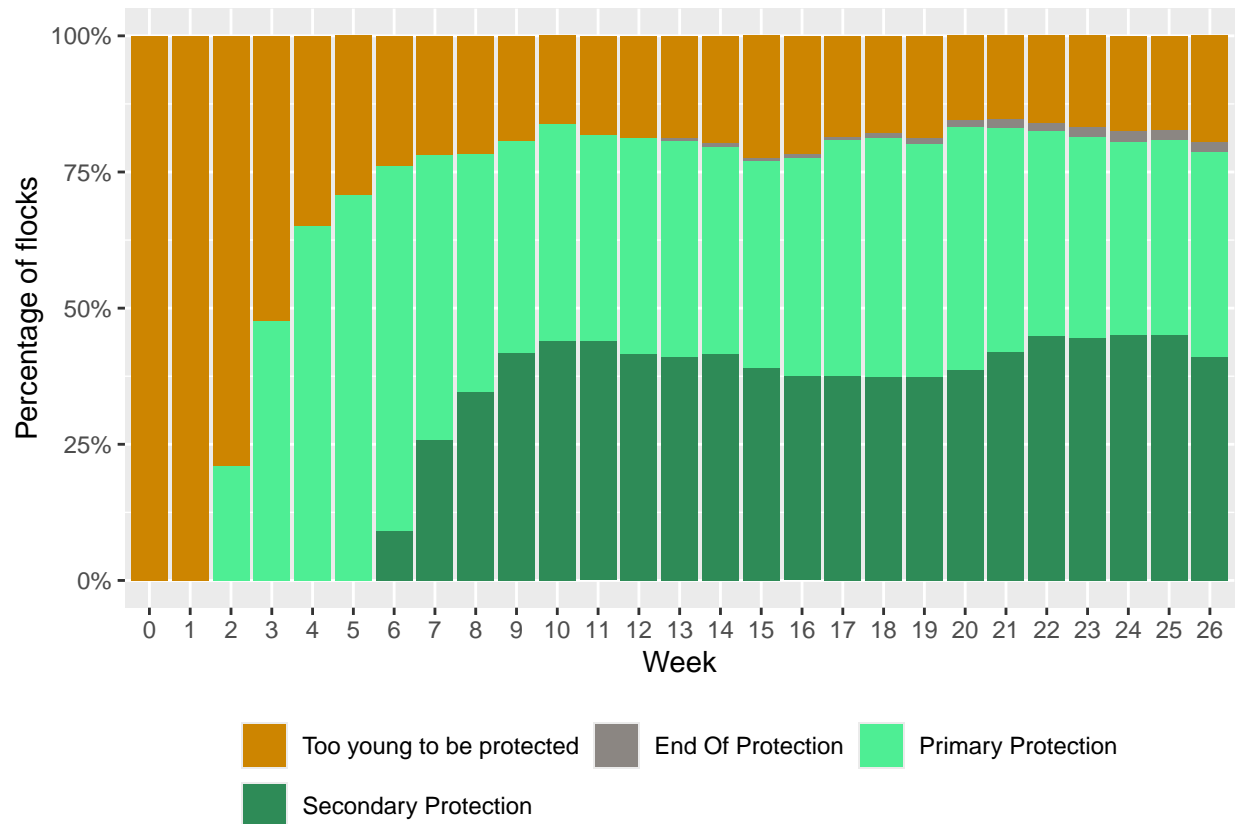
Theoretical vaccination model for meat ducks

The model is sourced from the file “Vaccination_Chair.R”. It incorporates the population dynamics described above, directly integrating the placement data (MEP) and the distributions of rearing durations.

The timing of the different vaccination phases is defined based on theoretical protocols. The first visit is scheduled between 10 and 21 days of age, with a higher uniform probability between 10 and 15 days than during the following period (up to 21 days), reflecting field observations. The second vaccination must take place no later than 23 days after the first. A time window between 18 and 23 days is considered.

The model produces a list with two outputs: the raw results and the associated plot.

```
sortie<- Vaccination_Modele_Chair(nweeks=26,ninit=MEP[1,2],Sale=Sale,MEP=MEP)
sortie_chair<-sortie[[2]]
sortie_chair
```



Fattening duck sector

```
# Load the CSV file containing vaccination data for meat ducks
Vacc_gras=read.delim("data_vacc_IAHP_gras.csv",header = TRUE,sep=";")

nb_nonVacc=sum(is.na(Vacc_gras$Age_V1))      ### 641
nb_V1_Unique=sum(!is.na(Vacc_gras$Age_V1) & is.na(Vacc_gras$Age_V2))  ### 164
nb_V1_is_V2=sum(Vacc_gras$Age_V1==Vacc_gras$Age_V2,na.rm = T)  ### 5

Cleaned_Vacc_gras=Vacc_gras[which(!(is.na(Vacc_gras$Age_V1)) &
                                   !(is.na(Vacc_gras$Age_V1) & is.na(Vacc_gras$Age_V2)) &
                                   !(Vacc_gras$Age_V1==Vacc_gras$Age_V2)),]
```

Number of flocks without vaccination : 641

Number of flocks with only V1 : 626

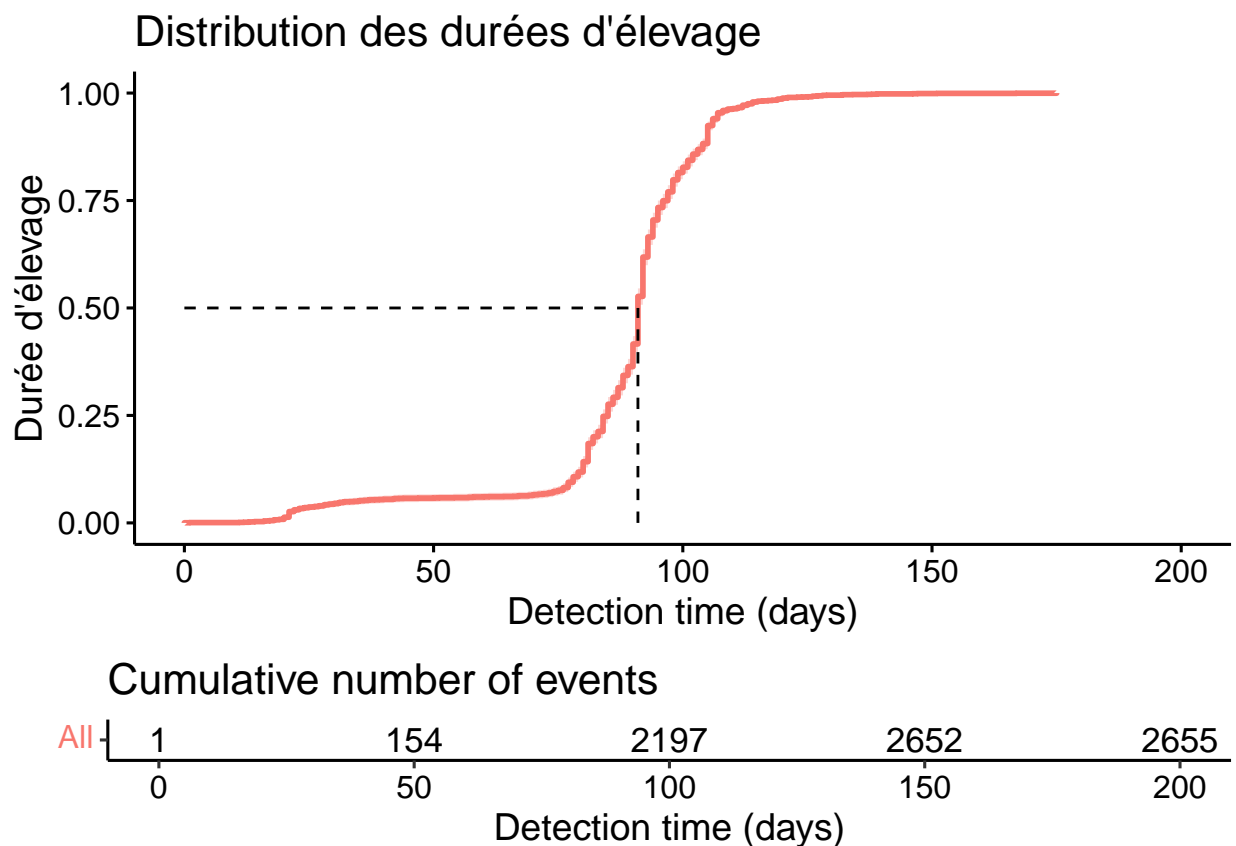
Number of flocks with V1=V2 : 4

Duration analysis

```
# Convert date columns to R Date format
Vacc_gras$Date_sortie=as.Date(Vacc_gras$Date_sortie_calc,format='%Y-%m-%d')
# Convert date columns to R Date format
Vacc_gras$Date_MEP=as.Date(Vacc_gras$Date_mep1,format='%Y-%m-%d')
```

```
Vacc_gras$DureeLot=Vacc_gras$Date_sortie -Vacc_gras$Date_MEP

# Create a survival object for duration analysis
S=Surv(Vacc_gras$DureeLot,! (Vacc_gras$DureeLot<0))
# Plot the survival curve based on flock durations
survPlot<-ggsurvplot(survfit(S~1,
                           data=Vacc_gras), fun="event",
                           Vacc_gras,
                           cumevents=TRUE,#risk.table = "nrisk_cumevents",
                           title=paste("Distribution des durées d\'élevage"),
                           legend.title="",legend="none",xlab="Detection time (days)",
                           ylab="Durée d\'élevage",
                           surv.median.line = "hv"#ncensor.plot=TRUE,
                           )
survPlot
```

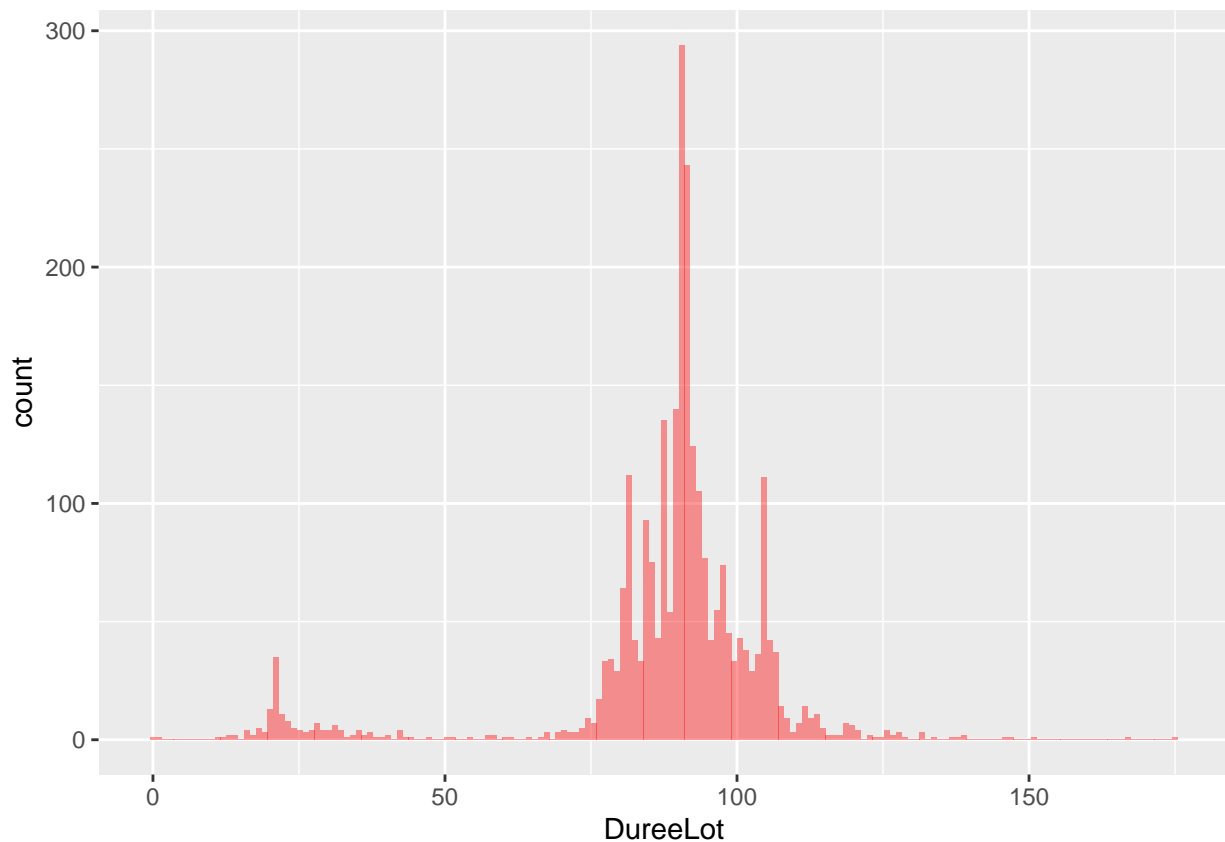


```
ggplot(data=Vacc_gras,aes(x=DureeLot))+
  geom_histogram(
    bins = as.numeric(range(Vacc_gras$DureeLot,na.rm = T)[2]),
    fill = "red",
    alpha = 0.4
  )
```

```
## Don't know how to automatically pick scale for object of type <difftime>.
## Defaulting to continuous.

## Warning: Removed 1316 rows containing non-finite outside the scale range
```

```
## (`stat_bin()`).
```



```
#Distribution cumulée des probabilité de départ à l'abattoir en fonction de l'âge.
tmp=cumsum(prop.table(table(Vacc_gras$DureeLot)))
Sale_Gras=data.frame(Age=as.numeric(names(tmp)),proba=as.numeric(tmp))
```

Flock introductions

The MEP database defined below records the daily number of flocks placed during the study period

```
# Analysis of daily placement data
# Convert date columns to R Date format
cbind(day=as.numeric(as.Date(names(table(Vacc_gras$Date_MEP))))-19631,nintro=table(Vacc_gras$Date_MEP,Vacc_gras$eli_V3))

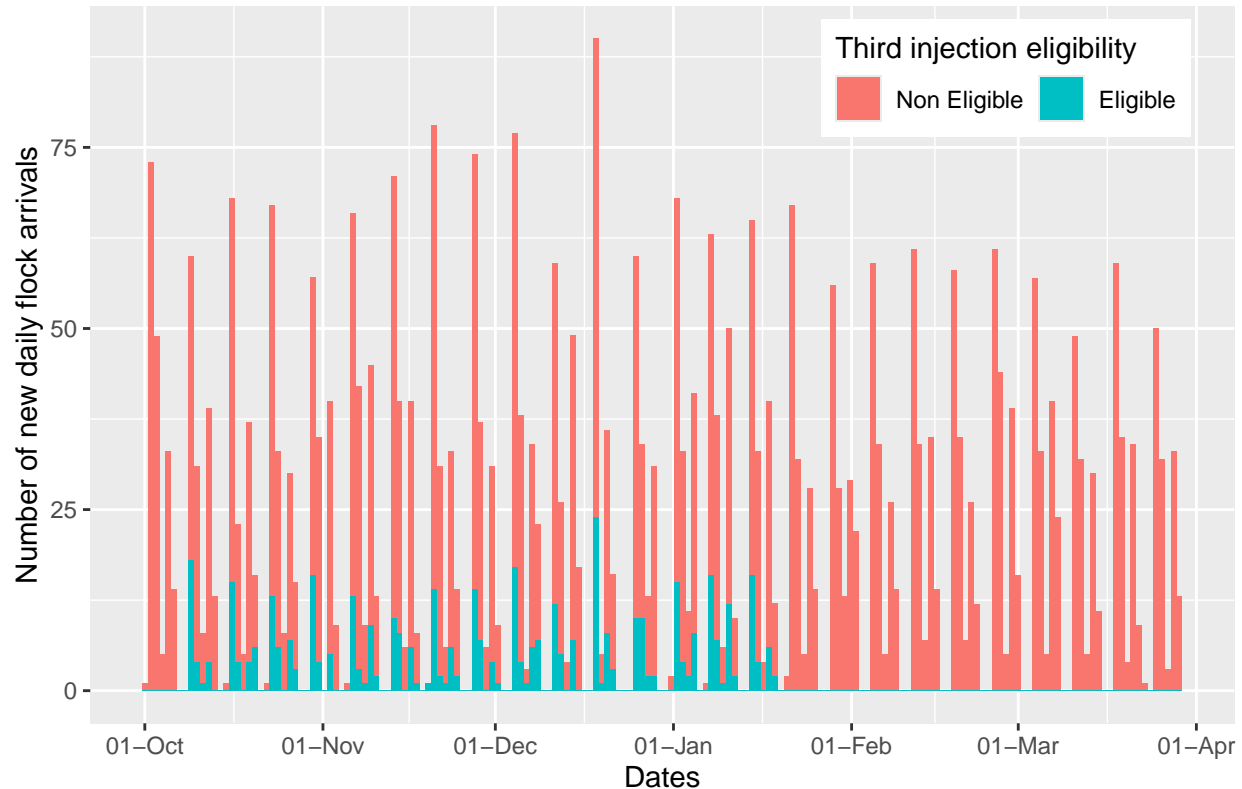
Vacc_gras$eli_V3<-factor(Vacc_gras$eli_V3)
levels(Vacc_gras$eli_V3)=c('Non Eligible','Eligible')
#FGraph associé à MEP
plot_MEP_Gras <- ggplot(data=Vacc_gras,aes(x=Date_MEP,fill=eli_V3))+
  geom_histogram(
    bins = as.numeric(max(Vacc_gras$Date_MEP)-min(Vacc_gras$Date_MEP))) +
  xlab("Dates") +
  ylab("Number of new daily flock arrivals")+theme(legend.position = c(0.8, 0.9),legend.title.position = c(0.8, 0.9))
  ggtitle("(b) Fattening Ducks") +
  guides( fill = guide_legend(title = element_text("Third injection eligibility"),ncol = 2, byrow=TRUE))
  scale_x_date(date_breaks = "1 month", date_labels = "%d-%b")
```

```
## Warning: A numeric `legend.position` argument in `theme()` was deprecated in ggplot2
```

```
## 3.5.0.
## i Please use the `legend.position.inside` argument of `theme()` instead.
## This warning is displayed once every 8 hours.
## Call `lifecycle::last_lifecycle_warnings()` to see where this warning was
## generated.
```

```
plot_MEP_Gras
```

(b) Fattening Ducks



```
#ggsave("C:/Users/m.salines/Desktop/Fig2.png", plot = grid.arrange(plot_MEP_Chair, plot_MEP_Gras), width=
```

Data related to the practice of the third dose

The third dose is mandatory dans 73 communes du plan Adour et 45 communes du plan Vendée militaire. Excluded from this obligation les canards mulards âgés de plus de 56 jours au 04 décembre 2023 et les canards mulards abattus avant l'âge de 11 semaine.

The third dose remains voluntary dans le reste des ZRD, avec priorité aux zones de recouvrement avec les ZRP. Elle est également volontaire autour des sites de sélection (périmètre de 3km) et multiplication (1 km).

A delay in the second dose is defined avec un délivrance à 33 jours au lieu de 28 jours d'âge.

```
sum(Vacc_gras$eli_V3=="Eligible")->eliV3
sum(is.na(Vacc_gras$Age_V3[which(Vacc_gras$eli_V3=="Eligible")])>tmp)/length(tmp)->prop_NonV3_EliV3
sum(!is.na(Vacc_gras$Age_V3[which(Vacc_gras$eli_V3=="Non Eligible")])>tmp)/length(tmp)->prop_V3_NonEliV3
```

Number of flocks eligible for third dose:429

Proportion of eligible flocks not vaccinated with third dose: 32.4009324 %

Proportion of non-eligible flocks vaccinated with third dose: 1.6092603 %

Theoretical vaccination model for meat ducks

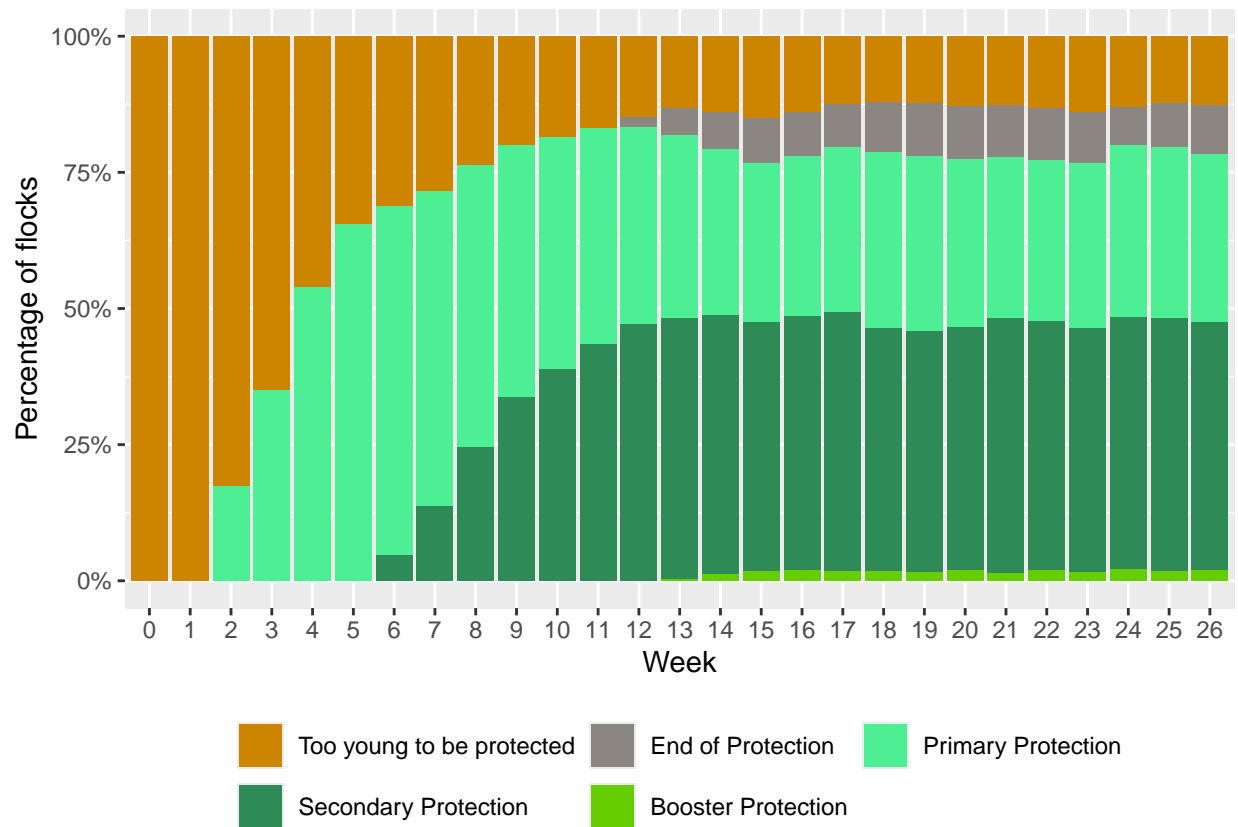
The model is sourced from the file “Vaccination_gras.R”. It incorporates the population dynamics described above, directly integrating the placement data (MEP) and the distributions of rearing durations.

The timing of the different vaccination phases is defined based on theoretical protocols. The first visit is scheduled between 10 and 21 days of age, with a higher uniform probability between 10 and 15 days than during the following period (up to 21 days), reflecting field observations. The second vaccination must take place no later than 23 days after the first. A time window between 18 and 23 days is considered.

The model produces a list with two outputs: the raw results and the associated plot.

```
sortie<- Vaccination_Modele_Gras(nweeks=26,nNonV3 = MEP_Gras[1,2] ,
sortie_gras <- sortie[[2]]
sortie_gras
```

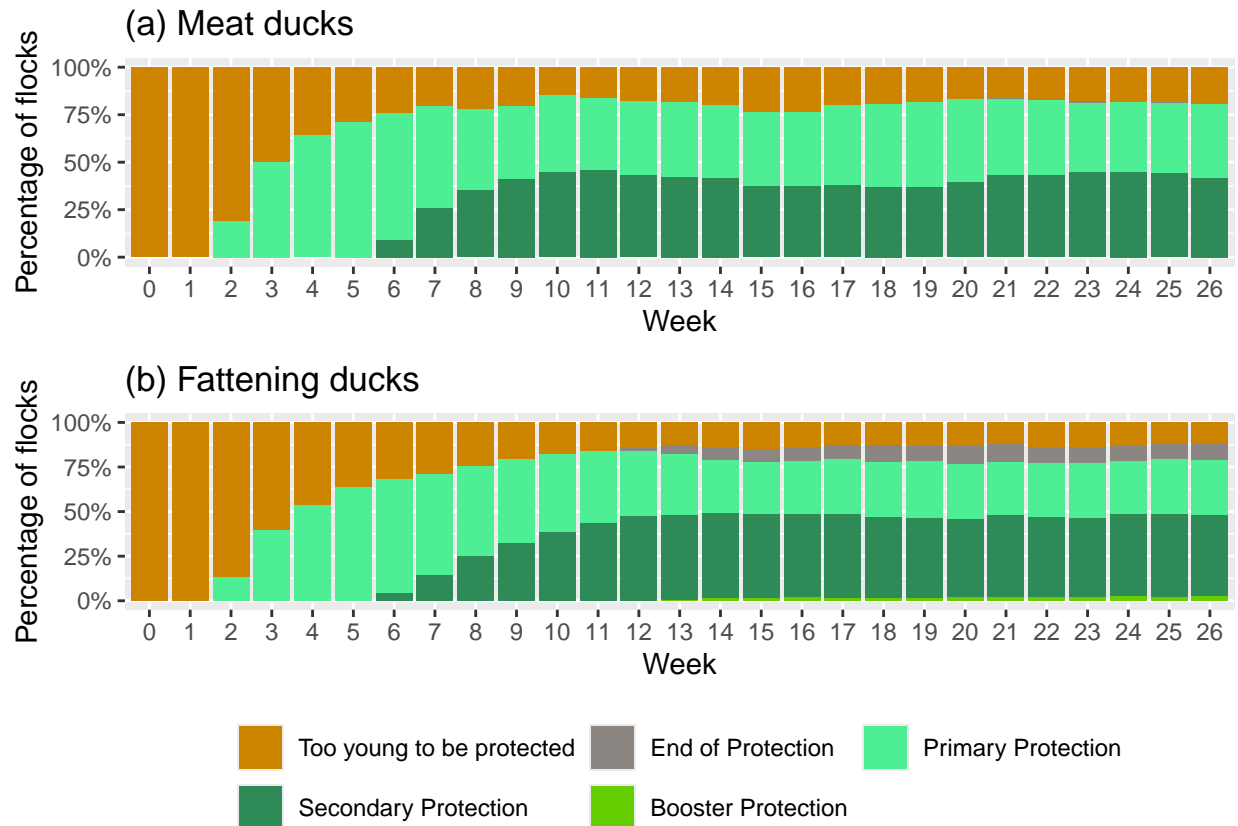
nV3=I



Supplementary material

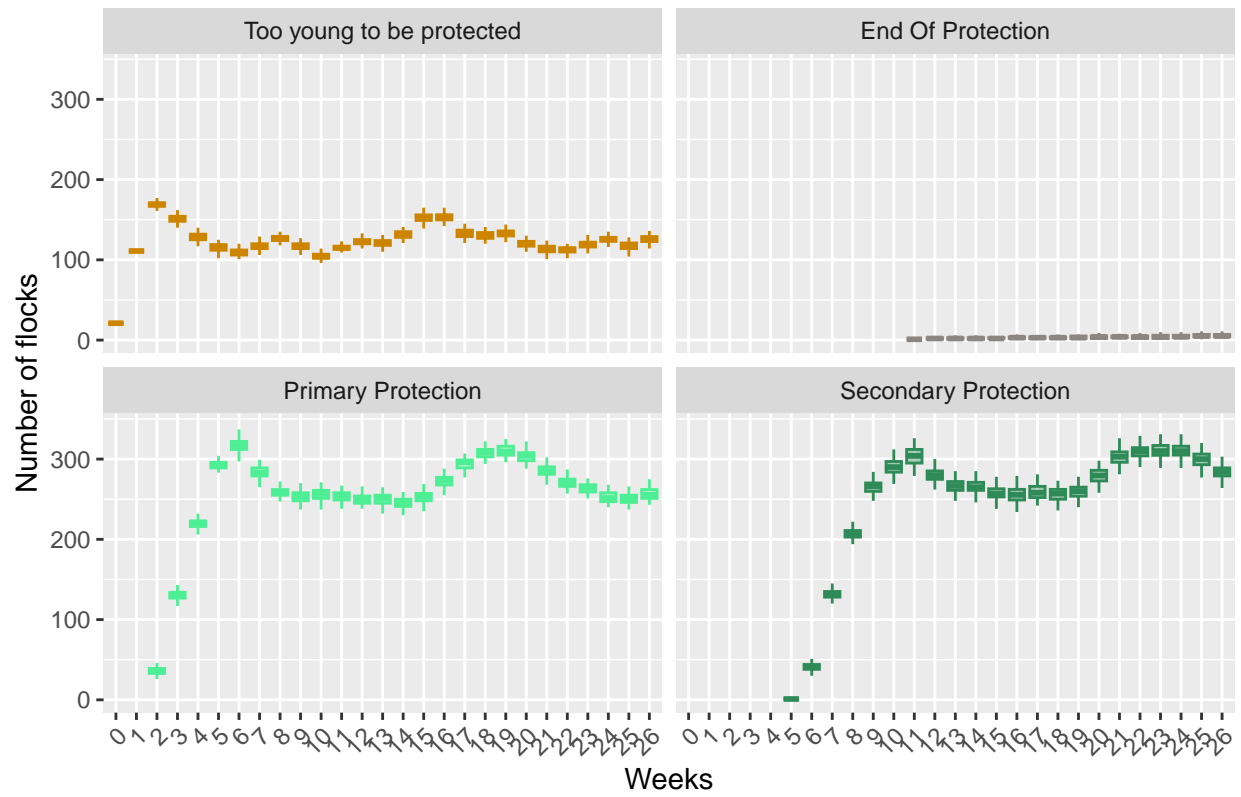
```
sortie<- Vaccination_Modele_Gras(nweeks=26,nNonV3 = MEP_Gras[1,2] ,
sortie_gras <- sortie[[2]]
sortie<- Vaccination_Modele_Chair(nweeks=26,ninit=MEP[1,2] ,Sale=Sale,MEP=MEP)
sortie_chair<-sortie[[2]]
sortie_chair<-sortie_chair+theme(legend.position="none")+ggtitle("(a) Meat ducks")
sortie_gras<-sortie_gras+ggtitle("(b) Fattening ducks")
plot <- grid.arrange(sortie_chair,sortie_gras,heights = c(0.7, 1))
```

nV3=I



```
ggsave("C:/Users/m.andraud/Desktop/SuppMat3.png", plot = plot, width = 10, height = 6, dpi = 600)
```

Meat ducks



Fattening ducks

