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Appendix 1. Code for fitting the Bayesian dispersal models using OpenBUGS

In fitting all models, we specified diffuse prior distributions, and we assessed convergence by eye. The Bateman model was fitted by running ten chains: after a "burn-in" of 4001 iterations, every 300th iteration was taken from a total of 1.5 million iterations. The Aylor model was fitted by running two chains: after a "burn-in" of 4001 iterations, every 100th iteration was taken from a total of 2 million iterations.

The Bateman model including the powered exponential curve (PEC)

Model code:

```
model{
      for(i in 1:N){
            Y[i] ~ dpois(mu[i])
            mu.temp[i] <- Lkappa[t[i],d[i]]-exp(exp(Lc[t[i],d[i]])*
                  (log(x[i])-Lal[t[i],d[i]])) # PEC
            Lmu[i] ~ dnorm(mu.temp[i],tau.mu) # Overdisp.,tau=1/(sigma^2)
            log(mu[i]) <- Lmu[i]
      }
# Hierarchical structure
      for(j in 1:Nt){
            Lkappa.t[j] ~ dnorm(Lkappa.mu, Lkappa.t.tau)
            Lal.t[j] ~ dnorm(Lal.mu, Lal.t.tau)
            Lc.t[j] ~ dnorm(Lc.mu, Lc.t.tau)
            for(k in 1: Nd){
                  Lkappa[j,k] ~ dnorm(Lkappa.t[j], Lkappa.tau)
                  Lal[j,k] ~ dnorm(Lal.t[j], Lal.tau)
                  Lc[j,k] ~ dnorm(Lc.t[j], Lc.tau)
            }
      }
# Prior distributions
# First term: mean; second term: precision=1/sqrt(standard deviation)
# The "L" before the parameter name refers to "log of"
tau.mu ~ dgamma(0.001,0.001)
Lkappa.mu ~ dnorm(0,0.000001)
Lkappa.t.tau ~ dgamma(0.001,0.001)
Lkappa.tau ~ dgamma(0.001,0.001)
Lal.mu ~ dnorm(0,0.1)
Lal.t.tau ~ dgamma(0.001,0.001)
Lal.tau ~ dgamma(0.001,0.001)
Lc.mu ~ dnorm(0,0.1)
Lc.t.tau ~ dgamma(0.001,0.001)
Lc.tau ~ dgamma(0.001,0.001)
}
```

Data:

```
list( N=28, Nt=2, Nd=2,
      t=c(1,1,1,1,1,1,1,1,1,1,1,1,1,1, 2,2,2,2,2,2,2,2,2,2,2,2,2,2),
      d=c(1,1,1,1,1,1,1,1,2,2,2,2,2,2,1,1,1,1,1,1,1,1, 2,2,2,2,2,2),
      x=c(2,3,4,5,6,7,8,9,2,3,4,5,6,7,2,3,4,5,6,7, 8,9,2,3,4,5,6,7),
```

```
      Y=c(210,55,32,35,14,12,6,1,271,95,37,16,12,3,71,21,17,6,4,1,0,0,91,31,
8,
            7,2,1))
```

Initial values:

```
list( tau.mu=0.25,Lkappa.mu=9.05,Lkappa.t.tau=10.8,Lkappa.tau=4.6,
      Lal.mu=-1.67,Lal.t.tau=7.7,Lal.tau=4.9,
      Lc.mu=-0.55,Lc.t.tau=246,Lc.tau=68)
list( tau.mu=0.25,Lkappa.mu=9.1,Lkappa.t.tau=10.1,Lkappa.tau=5,
      Lal.mu=-2,Lal.t.tau=8,Lal.tau=5,
      Lc.mu=-0.6,Lc.t.tau=250,Lc.tau=70)
list( tau.mu=0.23,Lkappa.mu=9.3,Lkappa.t.tau=10.2,Lkappa.tau=55.,
      Lal.mu=-2.2,Lal.t.tau=8.6,Lal.tau=5.2,
      Lc.mu=-0.65,Lc.t.tau=255,Lc.tau=77)
list( tau.mu=0.2,Lkappa.mu=9.4,Lkappa.t.tau=10.3,Lkappa.tau=5.,
      Lal.mu=-2.6,Lal.t.tau=8.3,Lal.tau=5.3,
      Lc.mu=-0.64,Lc.t.tau=258,Lc.tau=73)
list( tau.mu=0.23,Lkappa.mu=9.5,Lkappa.t.tau=10.4,Lkappa.tau=5.6,
      Lal.mu=-2.0,Lal.t.tau=8.7,Lal.tau=5.5,
      Lc.mu=-0.64,Lc.t.tau=256,Lc.tau=74)
list( tau.mu=0.24,Lkappa.mu=9.3,Lkappa.t.tau=10.5,Lkappa.tau=5.2,
      Lal.mu=-2.5,Lal.t.tau=8.6,Lal.tau=5.3,
      Lc.mu=-0.69,Lc.t.tau=257,Lc.tau=79)
list( tau.mu=0.26,Lkappa.mu=9.4,Lkappa.t.tau=10.6,Lkappa.tau=5.3,
      Lal.mu=-2.3,Lal.t.tau=8.4,Lal.tau=5.5,
      Lc.mu=-0.66,Lc.t.tau=257,Lc.tau=73)
list( tau.mu=0.24,Lkappa.mu=9.6,Lkappa.t.tau=10.7,Lkappa.tau=5.3,
      Lal.mu=-2.6,Lal.t.tau=8.5,Lal.tau=5.4,
      Lc.mu=-0.63,Lc.t.tau=253,Lc.tau=76)
list( tau.mu=0.24,Lkappa.mu=9.3,Lkappa.t.tau=10.8,Lkappa.tau=5.22,
      Lal.mu=-2.3,Lal.t.tau=8.6,Lal.tau=5.4,
      Lc.mu=-2,Lc.t.tau=253,Lc.tau=74)
list( tau.mu=0.23,Lkappa.mu=9.4,Lkappa.t.tau=10.9,Lkappa.tau=5.2,
      Lal.mu=-2.1,Lal.t.tau=8.3,Lal.tau=5.5,
      Lc.mu=-0.64,Lc.t.tau=257,Lc.tau=76)
```

The Bateman model including the t-distribution curve (tDC)

Model code:

```
model{
      for(i in 1:N) {
            Y[i] ~ dpois(mu[i])
            mu.temp[i] <- Lkappa[t[i],d[i]]+Lv[t[i],d[i]]-log(3.14)—
                  Leta[t[i],d[i]]-(exp(Lv[t[i],d[i]])+1)*
                  log(1+pow(x[i],2)/exp(Leta[t[i],d[i]]))-
                  log(x[i])   # tDC
            Lmu[i] ~ dnorm(mu.temp[i], tau.mu) # Overdisp.,tau=1/(sigma^2)
            log(mu[i]) <- Lmu[i]
      }
# Hierarchical structure
      for(j in 1:Nt){
            Lkappa.t[j] ~ dnorm(Lkappa.mu, Lkappa.t.tau)
            Lv.t[j] ~ dnorm(Lv.mu, Lv.t.tau)
            Leta.t[j] ~ dnorm(Leta.mu, Leta.t.tau)
            for(k in 1:Nd){
                  Lkappa[j,k] ~ dnorm(Lkappa.t[j], Lkappa.tau)
                  Lv[j,k] ~ dnorm(Lv.t[j], Lv.tau)
                  Leta[j,k] ~ dnorm(Leta.t[j], Leta.tau)
            }
      }
```

```
# Prior distributions
# First term: mean; second term: precision=1/(standard deviation^2)
# The "L" before the parameter name refers to "log of"
tau.mu ~ dgamma(0.001,0.001)
Lkappa.mu ~ dnorm(0,0.000001)
Lkappa.t.tau ~ dgamma(0.001,0.001)
Lkappa.tau ~ dgamma(0.001,0.001)
Lv.mu ~ dnorm(0,0.1)
Lv.t.tau ~ dgamma(0.001,0.001)
Lv.tau ~ dgamma(0.001,0.001)
Leta.mu ~ dnorm(0,0.1)
Leta.t.tau ~ dgamma(0.001,0.001)
Leta.tau ~ dgamma(0.001,0.001)
}
```

Data:
See above.

Initial values:

```
list( tau.mu=0.25,Lkappa.mu=9.0,Lkappa.t.tau=10.8,Lkappa.tau=0.5,
      Lv.mu=-1.67,Lv.t.tau=7.7,Lv.tau=4.9,
      Leta.mu=-0.55,Leta.t.tau=125,Leta.tau=68)
list( tau.mu=0.25,Lkappa.mu=9.1,Lkappa.t.tau=10.1,Lkappa.tau=0.4,
      Lv.mu=-2,Lv.t.tau=8,Lv.tau=5,
      Leta.mu=-0.6,Leta.t.tau=120,Leta.tau=70)
list( tau.mu=0.27,Lkappa.mu=9.2,Lkappa.t.tau=10.2,Lkappa.tau=0.45,
      Lv.mu=-1.7,Lv.t.tau=7.6,Lv.tau=4.8,
      Leta.mu=-0.56,Leta.t.tau=120,Leta.tau=67)
list( tau.mu=0.22,Lkappa.mu=9.3,Lkappa.t.tau=10.3,Lkappa.tau=0.43,
      Lv.mu=-1.73,Lv.t.tau=7.6,Lv.tau=4.4,
      Leta.mu=-0.53,Leta.t.tau=128,Leta.tau=64)
list( tau.mu=0.26,Lkappa.mu=9.3,Lkappa.t.tau=10.4,Lkappa.tau=0.45,
      Lv.mu=-1.73,Lv.t.tau=7.4,Lv.tau=4.6,
      Leta.mu=-0.58,Leta.t.tau=129,Leta.tau=65)
list( tau.mu=0.23,Lkappa.mu=9.2,Lkappa.t.tau=10.5,Lkappa.tau=0.49,
      Lv.mu=-1.73,Lv.t.tau=7.4,Lv.tau=4.7,
      Leta.mu=-0.55,Leta.t.tau=127,Leta.tau=65)
list( tau.mu=0.24,Lkappa.mu=9.3,Lkappa.t.tau=10.6,Lkappa.tau=0.45,
      Lv.mu=-1.73,Lv.t.tau=7.3,Lv.tau=4.4,
      Leta.mu=-0.59,Leta.t.tau=120,Leta.tau=65)
list( tau.mu=0.25,Lkappa.mu=9.3,Lkappa.t.tau=10.7,Lkappa.tau=0.43,
      Lv.mu=-1.75,Lv.t.tau=7.2,Lv.tau=4.6,
      Leta.mu=-0.53,Leta.t.tau=128,Leta.tau=65)
list( tau.mu=0.24,Lkappa.mu=9.3,Lkappa.t.tau=10.8,Lkappa.tau=0.47,
      Lv.mu=-1.75,Lv.t.tau=7.3,Lv.tau=4.2,
      Leta.mu=-0.57,Leta.t.tau=120,Leta.tau=66)
list( tau.mu=0.24,Lkappa.mu=9.3,Lkappa.t.tau=10.9,Lkappa.tau=0.43,
      Lv.mu=-1.72,Lv.t.tau=7.8,Lv.tau=4.9,
      Leta.mu=-0.54,Leta.t.tau=125,Leta.tau=67)
```

The Aylor model including the powered exponential curve (PEC)

Text after the sign # is not compiled.

Model code:

```
model{
      for(i in 1:N){
            Y[i] ~ dpois(mu[i])
            mu.temp[i] <- Lkappa[t[i]]-exp(exp(Lc[t[i]])*(log(x[i])-
                  Lal[t[i]])) # PEC
            Lmu[i] ~ dnorm(mu.temp[i],tau.mu)  # Overdisp.,tau=1/(sigma^2)
```

```
            log(mu[i]) <-Lmu[i]
      }
# Hierarchical structure
# Effect of wind speed on parameters
      for(j in 1:D){
#           Lkappa.mu[j] <- beta0.Lkappa+beta.Lkappa*(W[j]-windbar)
#           Lkappa[j] ~ dnorm(Lkappa.mu[j], Lkappa.tau)
            Lkappa[j] ~ dnorm(Lkappa.c, Lkappa.tau)
#           Lal.mu[j] <- beta0.Lal+beta.Lal*(W[j]-windbar)
#           Lal[j] ~ dnorm(Lal.mu[j], Lal.tau)
            Lal[j] ~ dnorm(Lal.c, Lal.tau)
#           Lc.mu[j] <- beta0.Lc+beta.Lc*(W[j]-windbar)
#           Lc[j] ~ dnorm(Lc.mu[j], Lc.tau)
            Lc[j] ~ dnorm(Lc.c, Lc.tau)
      }
# Prior distributions
# First term: mean; second term: precision=1/(standard deviation^2)
# The "L" before the parameter name refers to "log of"
tau.mu ~ dgamma(0.001,0.001)
# beta0.Lkappa ~ dnorm(0,0.1)
# beta.Lkappa ~ dnorm(0,0.1)
Lkappa.c ~ dnorm(0,0.1)
Lkappa.tau ~ dgamma(0.001,0.001)
# beta0.Lal ~ dnorm(0,0.1)
# beta.Lal ~ dnorm(0,0.1)
Lal.c ~ dnorm(0,0.1)
Lal.tau ~ dgamma(0.001,0.001)
# beta0.Lc ~ dnorm(0,0.1)
# beta.Lc ~ dnorm(0,0.1)
Lc.c ~ dnorm(0,0.1)
Lc.tau ~ dgamma(0.001,0.001)
}
```

Data:

```
list( N=64,D=10,#windbar=2.107,
      #wind=c(1.83,1.83,1.4,1.4,1.83,2.7,2.27,0.98,2.04,4.79),
      t=c(1,1,1,1,1,1,2,2,2,2,2,2,3,3,3,3,3,4,4,4,4,4,5,5,5,5,5,5,5,6,6,6,6,
            6,6,6,7,7,7,7,7,7,7,8,8,8,8,8,8,8,9,9,9,9,9,9,9,10,10,10,10,10,1
            0,10),
      Y=c(778,271,116,55,67,34,442,123,92,37,23,25,1545,371,257,138,91,894,
            344,162,123,66,60,35,24,24,11,6,5,1236,853,675,392,301,194,118,
            1605,1121,847,625,337,238,94,1397,681,611,506,203,140,61,3749,
            1760,839,868,623,500,227,2342,1355,935,641,475,233,167),
      x=c(0.1,0.5,1,1.5,2,3,0.1,0.5,1,1.5,2,3,0.1,0.5,1,1.5,2,0.1,0.5,1,
            1.5,2,0.1,0.2,0.4,0.6,1,1.9,3.7,0.1,0.2,0.4,0.6,1,1.9,3.7,0.1,0.
      2,
            0.4,0.6,1,1.9,3.7,0.1,0.2,0.4,0.6,1,1.9,3.7,0.1,0.2,0.4,0.6,1,1.
      9,
            3.7,0.1,0.2,0.4,0.6,1,1.9,3.7))
```

Initial values:

```
list( tau.mu = 1,
#     beta0.Lkappa=8.401,betaW.Lkappa=0,Lkappa.tau=1,
      Lkappa.c=8.401,Lkappa.tau=1,
#     beta0.Lal=-4.667,betaW.Lal=0,Lal.tau=10,
      Lal.c=-4.667,Lal.tau=10,
#     beta0.Lc=-1.168,betaW.Lc=0,Lc.tau=10)
      Lc.c=-1.168,Lc.tau=10)
list( tau.mu=1,
#     beta0.Lkappa=8.401,betaW.Lkappa=0,Lkappa.tau=1,
      Lkappa.c=8.501,Lkappa.tau=1.1,
#     beta0.Lal=-4.767,betaW.Lal=0,Lal.tau=11,
      Lal.c=-4.767,Lal.tau=11,
```

```
#      beta0.Lc=-1.268,betaW.Lc=0,Lc.tau=11)
       Lc.c=-1.268,Lc.tau=11)
```

The Aylor model including the t-distribution curve (tDC)

Text after the sign # is not compiled.

Model code:

```
model{
      for(i in 1:N){
            Y[i]~dpois(mu[i])
            mu.temp[i] <- Lkappa[t[i]]-(exp(Lv[t[i]])+1)/
                  2*log(1+exp(2*(log(x[i])—Leta[t[i]])-Lv[t[i]])) # tDC
            Lmu[i] ~ dnorm(mu.temp[i],tau.mu) #Overdisp.,tau=1/(sigma^2)
            log(mu[i]) <- Lmu[i]
      }
# Hierarchical structure
# Effect of wind speed on parameters      for(j in 1:D){
#           Lkappa.mu[j] <- beta0.Lkappa+beta.Lkappa*(W[j]-windbar)
#           Lkappa[j] ~ dnorm(Lkappa.mu[j], Lkappa.tau)
            Lkappa[j] ~ dnorm(Lkappa.c, Lkappa.tau)
#           Lv.mu[j] <- beta0.Lv+beta.Lv*(W[j]-windbar)
#           Lv[j] ~ dnorm(Lv.mu[j], Lv.tau)
            Lv[j] ~ dnorm(Lv.c, Lv.tau)
#           Leta.mu[j] <- beta0.Leta+beta.Leta*(W[j]-windbar)
#           Leta[j] ~ dnorm(Leta.mu[j], Leta.tau)
            Leta[j] ~ dnorm(Leta.c, Leta.tau)
      }
# Prior distributions
# First term: mean; second term: precision=1/(standard deviation^2)
# The "L" before the parameter name refers to "log of"
tau.mu ~ dgamma(0.001,0.001)
# beta0.Lkappa ~ dnorm(0,0.1)
# beta.Lkappa ~ dnorm(0, 0.1)
Lkappa.c ~ dnorm(0,0.1)
Lkappa.tau ~ dgamma(0.001,0.001)
# beta0.Lv ~ dnorm(0,0.1)
# beta.Lv ~ dnorm(0, 0.1)
Lv.c ~ dnorm(0,0.1)
Lv.tau ~ dgamma(0.001,0.001)
# beta0.Leta ~ dnorm(0,0.1)
# beta.Leta ~ dnorm(0, 0.1)
Leta.c ~ dnorm(0,0.1)
Leta.tau ~ dgamma(0.001,0.001)
}
```

Data:

See above.

Initial values:

```
list( tau.mu=1,
#      beta0.Lkappa=8.401,betaW.Lkappa=0,Lkappa.tau=1,
       Lkappa.c=8.401,Lkappa.tau=1,
#      beta0.Lal=-4.667,betaW.Lal=0,Lal.tau=10,
       Lv.c=-4.667,Lv.tau=1,
#      beta0.Lc=-1.168,betaW.Lc=0,Lc.tau=10)
       Leta.c=-1.168,Leta.tau=1)
list( tau.mu=1,
#      beta0.Lkappa=8.401,betaW.Lkappa=0,Lkappa.tau=1,
       Lkappa.c=8.501,Lkappa.tau=1,
#      beta0.Lal=-4.767,betaW.Lal=0,Lal.tau=11,
```

```
       Lv.c=-4.767,Lv.tau=1,
#      beta0.Lc=-1.268,betaW.Lc=0,Lc.tau=11)
       Leta.c=-1.268,Leta.tau=1)
```