**Appendix S1: Full model selection**

Best selected models based on QAICc modelling survival (s), dispersal (psi) and detection probabilities (p). Model in bold is the most parcimonious one.

*t* is fully-time dependence, c2 and c3 respectively consider 2 and 3 cohorts on survival, 2T considers two periods 2011-2016;2019-2022 (no outbreak) and 2017-2018 (outbreak) on dispersal, 1T is one period 2011-2022 on dispersal; 2f is state dependence on detection.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Model | # Id. Par. | Deviance | QAIC | QAICc | AICcWeight |
| s(c2.t)psi(2T)p(2f) | **31** | **1846.381** | **1908.381** | **1909.5783** | **0** |
| s(c2.t)psi(1T)p(2f) | 25 | 1863.6626 | 1913.6626 | 1914.4443 | 4.9 |
| s(c3.t)psi(2T)p(2f) | 35 | 1845.2729 | 1915.2729 | 1916.7974 | 7.2 |
| s(c2.t)psi(3T)p(2f) | 37 | 1842.902 | 1916.902 | 1918.6052 | 9.0 |
| s(t)psi(2T)p(2f) | 25 | 1867.5549 | 1917.5549 | 1918.3366 | 8.8 |
| s(c3+t)psi(2T)p(2f) | 27 | 1864.3688 | 1918.3688 | 1919.2791 | 9.7 |
| s(c3.t)psi(1T)p(2f) | 29 | 1862.4505 | 1920.4505 | 1921.4993 | 11.9 |
| s(t)psi(1T)p(2f) | 19 | 1884.6895 | 1922.6895 | 1923.1449 | 13.6 |
| s(c3+t)psi(1T)p(2f) | 21 | 1881.5787 | 1923.5787 | 1924.133 | 14.6 |
| s(c2.t)psi(2T)p(i) | 29 | 1868.5175 | 1926.5175 | 1927.5663 | 18.0 |
| s(c3.t)psi(3T)p(2f) | 43 | 1841.7904 | 1927.7904 | 1930.0907 | 20.5 |
| s(t)psi(3T)p(2f) | 33 | 1864.0599 | 1930.0599 | 1931.4158 | 21.8 |
| s(3c+t)psi(3T)p(2f) | 35 | 1860.8853 | 1930.8853 | 1932.4098 | 22.8 |
| s(c2.t)psi(1T)p(i) | 24 | 1883.5733 | 1931.5733 | 1932.2944 | 22.7 |
| s(c3.t)psi(2T)p(i) | 34 | 1867.3094 | 1935.3094 | 1936.7484 | 27.2 |
| s(c2.t)psi(3T)p(i) | 35 | 1866.6182 | 1936.6182 | 1938.1427 | 28.6 |
| s(t)psi(2T)p(i) | 25 | 1889.5313 | 1939.5313 | 1940.3131 | 30.7 |
| s(c3.t)psi(1T)p(i) | 29 | 1882.3649 | 1940.3649 | 1941.4137 | 31.8 |
| s(c3+t)psi(2T)p(i) | 27 | 1886.4327 | 1940.4327 | 1941.343 | 31.8 |
| s(t)psi(1T)p(i) | 20 | 1904.5871 | 1944.5871 | 1945.0907 | 35.5 |
| s(c3)psi(2T)p(2f) | 16 | 1912.9841 | 1944.9841 | 1945.3094 | 35.7 |
| s(c3.t)psi(3T)p(i) | 40 | 1865.4093 | 1945.4093 | 1947.3996 | 37.8 |
| s(c3+t)psi(1T)p(i) | 22 | 1901.4885 | 1945.4885 | 1946.0959 | 36.5 |
| s(t)psi(3T)p(i) | 31 | 1887.6313 | 1949.6313 | 1950.8287 | 41.3 |
| s(c3+t)psi(3T)p(i) | 33 | 1884.5327 | 1950.5327 | 1951.8886 | 42.3 |
| s(i)psi(2T)p(2f) | 14 | 1923.8313 | 1951.8313 | 1952.0822 | 42.5 |
| s(c3)psi(1T)p(2f) | 12 | 1930.6966 | 1954.6966 | 1954.8828 | 45.3 |
| s(c2)psi(2T)p(2f) | 16 | 1923.7048 | 1955.7048 | 1956.0302 | 46.5 |
| s(c3)psi(3T)p(2f) | 24 | 1909.4812 | 1957.4812 | 1958.2024 | 48.6 |
| s(i)psi(1T)p(2f) | 8 | 1941.7154 | 1957.7154 | 1957.8011 | 48.2 |
| s(i)psi(3T)p(2f) | 20 | 1920.3829 | 1960.3829 | 1960.8865 | 51.3 |
| s(c2)psi(1T)p(2f) | 10 | 1941.5691 | 1961.5691 | 1961.7002 | 52.1 |
| s(c2)psi(3T)p(2f) | 22 | 1920.2545 | 1964.2545 | 1964.8619 | 55.3 |
| s(c3)psi(2T)p(i) | 16 | 1935.5432 | 1967.5432 | 1967.8686 | 58.3 |
| s(c3)psi(1T)p(i) | 11 | 1950.599 | 1972.599 | 1972.7564 | 63.2 |
| s(i)psi(2T)p(i) | 14 | 1946.6207 | 1974.6207 | 1974.8716 | 65.3 |
| s(c2)psi(2T)(i) | 15 | 1946.4715 | 1976.4715 | 1976.7584 | 67.2 |
| s(c3)psi(3T)p(i) | 22 | 1933.6432 | 1977.6432 | 1978.2507 | 68.7 |
| s(i)psi(1T)p(i) | 9 | 1961.6765 | 1979.6765 | 1979.7837 | 70.2 |
| s(i)psi(3T)p(i) | 20 | 1944.7207 | 1984.7207 | 1985.2243 | 75.6 |
| s(c2)psi(3T)p(i) | 21 | 1944.5715 | 1986.5715 | 1987.1258 | 77.5 |

**Appendix S2: Multi-state modelling framework.**

Multi-site models use three sets of parameters: initial state probabilities (П, matrix 1), transition between states probabilities (Ψ’; matrix 2.1 and 2.2), and event probabilities (p, matrix 3). Transition probabilities are decomposed into two consecutive steps: survival probabilities (*s; matrix 2.1*) and movement probabilities ($ψ$; matrix 2.2).

 П =$ \left(\begin{matrix}π&-&-\end{matrix}\right)$ initial state

Ψ’= s \* Ψ

 S $=Survival=\left(\begin{matrix}\begin{matrix}s&-\\-&s\end{matrix}&\begin{matrix}-&\*\\-&\*\end{matrix}\\\begin{matrix}-&-\\-&-\end{matrix}&\begin{matrix}s&\*\\-&\*\end{matrix}\end{matrix}\right)$ matrix 2.1

Ψ$=Dispersal=\left(\begin{matrix}\begin{matrix}\*&y\\\*&z\end{matrix}&\begin{matrix}z&-\\y&-\end{matrix}\\\begin{matrix}\*&y\\-&-\end{matrix}&\begin{matrix}z&-\\-&\*\end{matrix}\end{matrix}\right)$ matrix 2.2

p$=Resighting =\left(\begin{matrix}\*&b&-&-\\\*&-&b&-\\\*&-&-&b\\\*&-&-&-\end{matrix}\right)$ matrix 3