

# **On exact and approximate approaches for stochastic receptor-ligand competition dynamics - An ecological perspective**

P.A. Jeffrey; M. López García; M. Castro Ponce; G. Lythe; C. Molina  
París

## **Abstract-**

Cellular receptors on the cell membrane can bind ligand molecules in the extra-cellular medium to form ligand-bound monomers. These interactions ultimately determine the fate of a cell through the resulting intra-cellular signalling cascades. Often, several receptor types can bind a shared ligand leading to the formation of different monomeric complexes, and in turn to competition for the common ligand. Here, we describe competition between two receptors which bind a common ligand in terms of a bi-variate stochastic process. The stochastic description is important to account for fluctuations in the number of molecules. Our interest is in computing two summary statistics—the steady-state distribution of the number of bound monomers and the time to reach a threshold number of monomers of a given kind. The matrix-analytic approach developed in this manuscript is exact, but becomes impractical as the number of molecules in the system increases. Thus, we present novel approximations which can work under low-to-moderate competition scenarios. Our results apply to systems with a larger number of population species (i.e., receptors) competing for a common resource (i.e., ligands), and to competition systems outside the area of molecular dynamics, such as Mathematical Ecology.

**Index Terms-** receptor-ligand interaction; continuous-time Markov chain; summary statistics; steady-state; first-passage time; approximation

Due to copyright restriction we cannot distribute this content on the web. However, clicking on the next link, authors will be able to distribute to you the full version of the paper:

[Request full paper to the authors](#)

If your institution has an electronic subscription to Mathematics, you can download the paper from the journal website:

[Access to the Journal website](#)

## **Citation:**

*Jeffrey, P.A.; López-García, M.; Castro, M.; Lythe, G.; Molina-Paris, C. "On exact and approximate approaches for stochastic receptor-ligand competition dynamics - An ecological perspective", Mathematics, vol.8, no.6, pp.1014-1-1014-31, June, 2020.*