Thesis title: Physiological mechanisms for the maintenance of nitrogen stoichiometric homeostasis in earthworms and implications for soil nitrogen dynamics in temperate agroecosystems

Suggested short title: Nitrogen stoichiometry in earthworms and implications for soil nitrogen dynamics in agroecosystems

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Earthworms contribute to nitrogen (N) cycling in agroecosystems through the direct release of N from their populations, and their indirect effects on soil physical, chemical and biological processes. Despite the large body of literature on earthworm ecology, studies that examine the direct role of earthworms on N cycling from the perspective of ecological stoichiometry are lacking. This knowledge gap needs to be addressed, particularly intemperate agroecosystems where earthworms are the dominant soil fauna based on their biomass. This study sought to provide insights into the physiological mechanisms regulating N stoichiometry in earthworm body, to better understand the stoichiometric interaction between earthworms and their food resources at the individual level, and the implications of crop residue quality on earthworm-mediated N dynamics at the agroecosystem level. First, I investigated whether the endogeic earthworm *Aporrectodea turgida* maintains a strict homeostasis in its body N concentration and C:N ratio in controlled laboratory experiment. This allowed me to evaluate some of the physiological mechanisms *A. turgida* can use to regulate its body N stoichiometry, namely secretion of external and internal mucus, selective ingestion, urine excretion, and *in vivo* gut-denitrification. Second, I conducted a field study on earthworm population dynamics in relation to crop residue quantity and quality, and soil particulate organic matter (POM) during a two-year period in no-till corn-soybean agroecosystems. Finally, I quantified the direct flux of N through the population of *Aporrectodea* spp. in no-till corn-soybean agroecosystems, by summing up N released from earthworms through secondary production and excretion (mucus, urine). As expected, *A. turgida* exhibited strict homeostasis in its body N concentration (11%) and C:N ratio (3.9), regardless of the N content (1.5-5.7%) and C:N ratio (8-29)of the organic materials ingested. Among the physiological mechanisms investigated, only selective ingestion and gut-denitrification are likely to contribute to the conservation of N stoichiometry in the body of A. *turgida*. This implies that in N-poor agroecosystems, earthworms will increase their ingestion rates to acquire the necessary amount of N to maintain their N stoichiometry, However, regardless of their food resources, *A. turgida* appear to maintain similar N excretion rate from urine and mucus, averaging 609 µg N g^{-1} fw d^{-1}, of which

36 to 84% was recovered in the mineral-N and dissolved organic nitrogen (DON) pools after two days. This finding is consistent with the observation that earthworm presence in temperate agroecosystems enhances N mineralization and plant growth. The field study showed that earthworm abundance and biomass were positively related to the amount of surface residue present in no-till agroecosystems, but were not correlated to the chemical composition of crop residue and the soil POM content during this two-year study. As the stoichiometric interaction between earthworms and their food resources under realistic field conditions were not related to these indicators of crop residue quality, I propose that future characterization of food quality should use more meaningful indicators (e.g., assimilable energy). My estimation of the direct N flux through the population of *Aporrectodea* spp. ranged from 22 to 105 kg N $ha^{-1}year^{-1}$, which may represent 24 to 88% of the recommended N fertilizer requirements of corn in Quebec. I conclude that the direct flux of N through earthworm populations is substantial, and likely contributes to the soil mineral N supply for crop production in no-till agroecosystems of Quebec, Canada. Refining the N fertilization recommendation for non-leguminous grain crops to account for N supply from earthworms has the potential to reduce costs and environmental losses of N.