

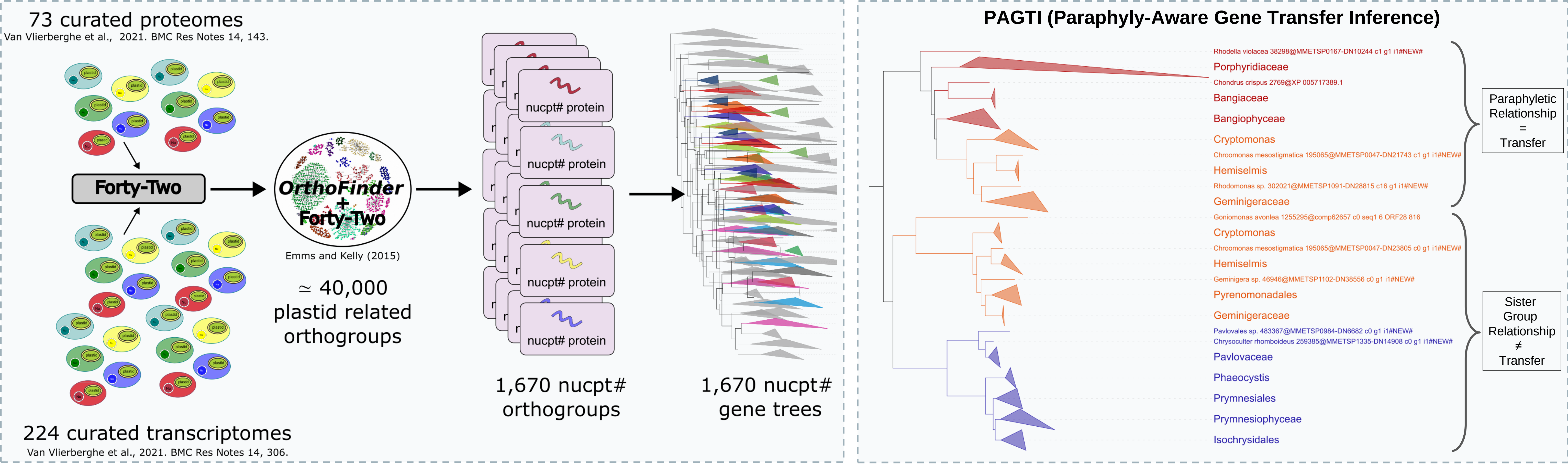
# Probing Endosymbiosis and Kleptoplasty in the Evolution of Complex Algae

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## 1 · BACKGROUND · endosymbiosis does not fully explain gene mosaicism

Photosynthetic eukaryotes are scattered across the tree of life, and the mechanisms by which their plastids were acquired remain among the most debated questions in evolutionary biology (Sibbald & Archibald, 2020). Classical models invoke endosymbiosis as the primary driver of plastid spread, yet nucleus-encoded plastid-targeted (nucpt#) genes often reveal mosaic phylogenetic origins (Dorrell et al., 2017) that are difficult to reconcile with simple single-donor scenarios. Several hypotheses have been proposed, including serial (possibly cryptic) endosymbiosis (Moustafa et al., 2009), the related Shopping Bag (Howe et al., 2008; Larkum et al., 2007; Morozov & Galachyants, 2019) and Red Carpet (Ponce-Toledo et al., 2018) models, and the Rhodoplex (Petersen et al., 2014) family of hypotheses. However, the selective processes linking transient plastid endosymbiotic associations to permanent integration remain incompletely understood. In contrast, kleptoplasty provides one possible solution to this problem, because the absence of a self-contained endosymbiont creates an immediate selective pressure for exploiting stolen plastids over increasing periods of time.

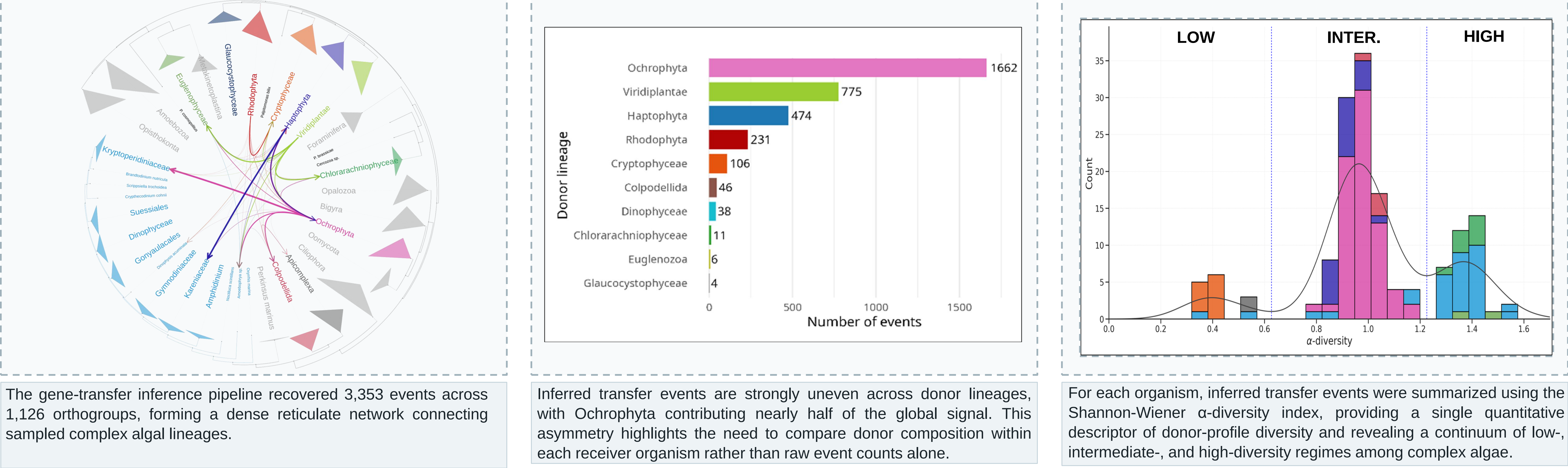
## 2 · FRAMEWORK · one high-quality dataset, one pipeline, all complex algae



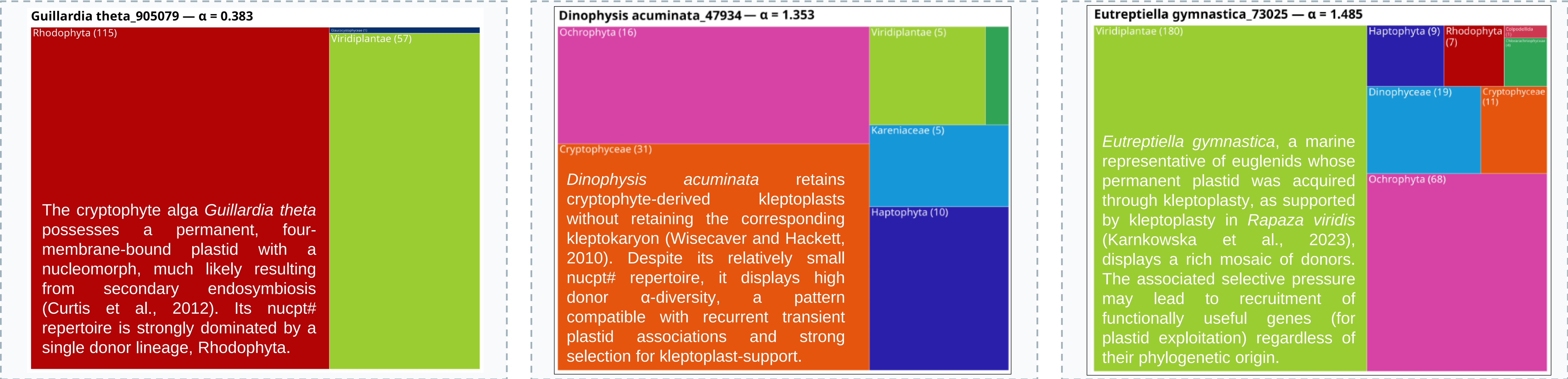
Curated proteomes and transcriptomes were integrated into a unified phylogenomic framework for reconstructing plastid-related orthogroups and nucpt# single gene trees. Contamination and redundancy were mitigated using several complementary curation and orthology-based approaches (Van Vlierberghe et al., 2021a,b).

PAGTI infers directional gene transfers when a monophyletic receiver clade is nested within a paraphyletic donor lineage. Unlike conventional sister group-based detection, it does not interpret simple sister relationships alone as evidence of transfer.

## 3 · QUANTITATIVE PHYLOGENOMICS APPROACH · $\alpha$ -diversity to summarize donor profiles



Donor  $\alpha$ -diversity summarizes how evenly inferred transfers are distributed among donor lineages; treemaps below illustrate three contrasting biological regimes.



## 4 · ALTERNATIVE MODEL · kleptoplasty as a donor-mosaicism ratchet

Transient kleptoplasts exposes the host to diverse plastid donors. Useful nucpt# genes are retained after each prey turnover, progressively building a mosaic before permanent plastid integration.

