F2: LeadingOnes

The LeadingOnes problem rewards solutions based on the number of consecutive 1-bits from the start of the string. Only flipping the leftmost incorrect bit can improve fitness, so progress is inherently step-wise and can be disrupted if earlier correct bits are flipped.

RandomSearch shows poor performance, making only negligible gains. The probability of randomly sampling long prefixes of 1s is very low, so RS's best-so-far values do not reach optimum.

RLS and (1+1) EA start with similar performance. Both show a flat line segment before any climb begins, reflecting that in many runs, the first bit was 0, and no improvement is possible until it is flipped to 1. After this occurs, they begin to show a slightly jagged rise rather than a smooth climb, which reflects the discrete nature of LeadingOnes, where improvements happen in single-bit increments and occasional regressions occur. RLS does edge ahead generally, before both algorithms converge before RLS pulls ahead to reach the plateau first. This earlier plateau for RLS suggests that its strict single-bit mutation is slightly more efficient at locking in progress, whereas (1+1) EA's occasional multi-bit flips can undo some gains before they are re-established.

Variance patterns mirror this behaviour: both hill-climbers show fluctuations early on, but RLS's variance narrows sooner as more runs synchronise on longer prefixes. RS maintains high variance throughout without meaningful progress.

Overall, RLS and (1+1) EA make steady gains, but RLS's single-bit flips give it a small but consistent edge in reaching the optimum sooner. The jagged curves and occasional crossovers reflect the problem's sequential dependency and the stochastic nature of the search.