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Study of Swimming Motility in the Bacterium Pseudomonas extremaustralis 2E-UNGS

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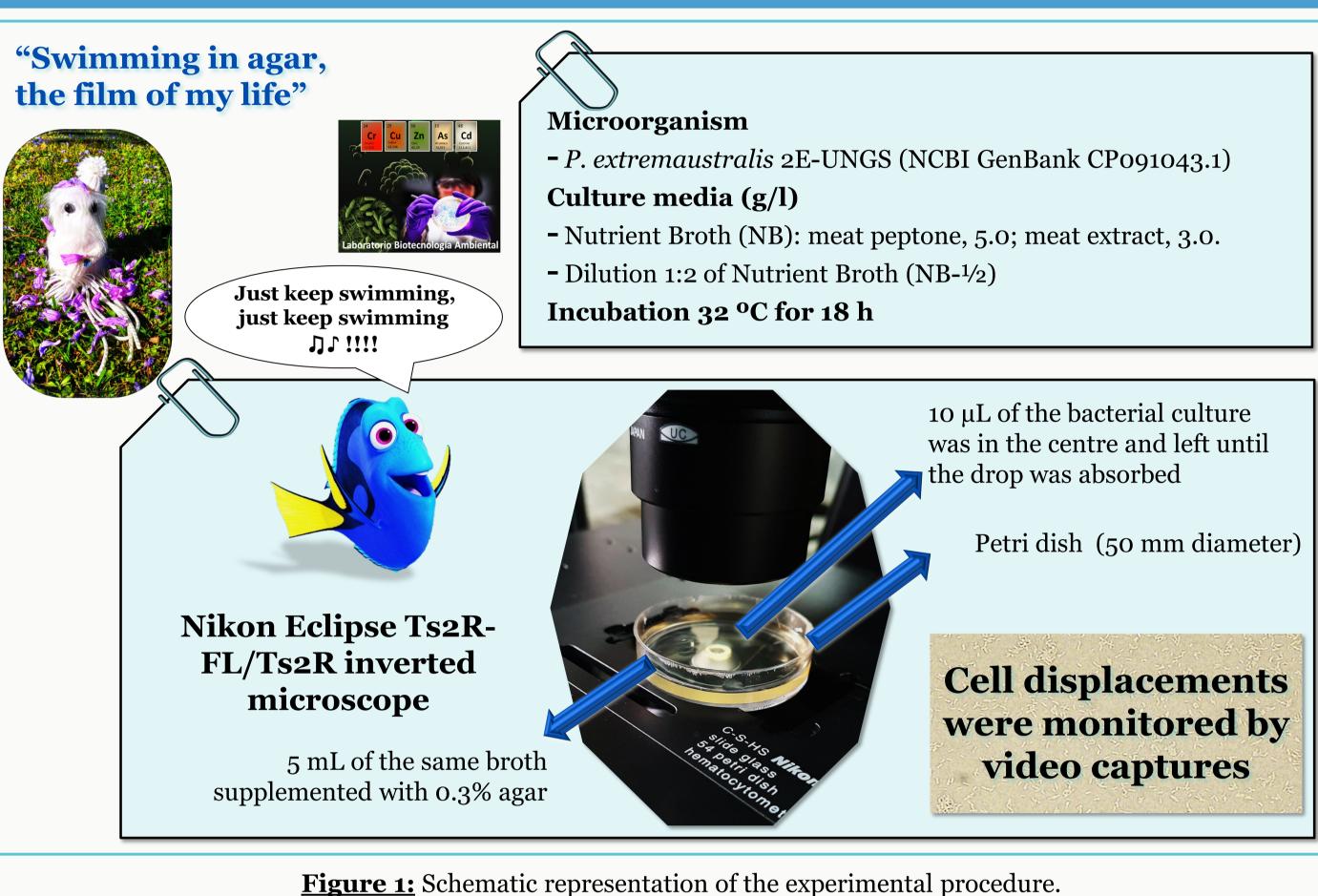
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INTRODUCTION

Pseudomonas extremaustralis 2E-UNGS exhibits both swimming and swarming motility, secretes surfactants and extracellular polymeric substances related to both biofilm formation and cell aggregation. This microorganism was isolated from the highly contaminated Reconquista River basin (Bs. As., Argentina) and reports relevant environmental interest for the metal biosorption from electroplating effluents.

OBJECTIVE

The aim of this work was to deepen in the characteristics of *P. extremaustralis* 2E-**UNGS** swimming motility integrating experimental observations with computational modelling.



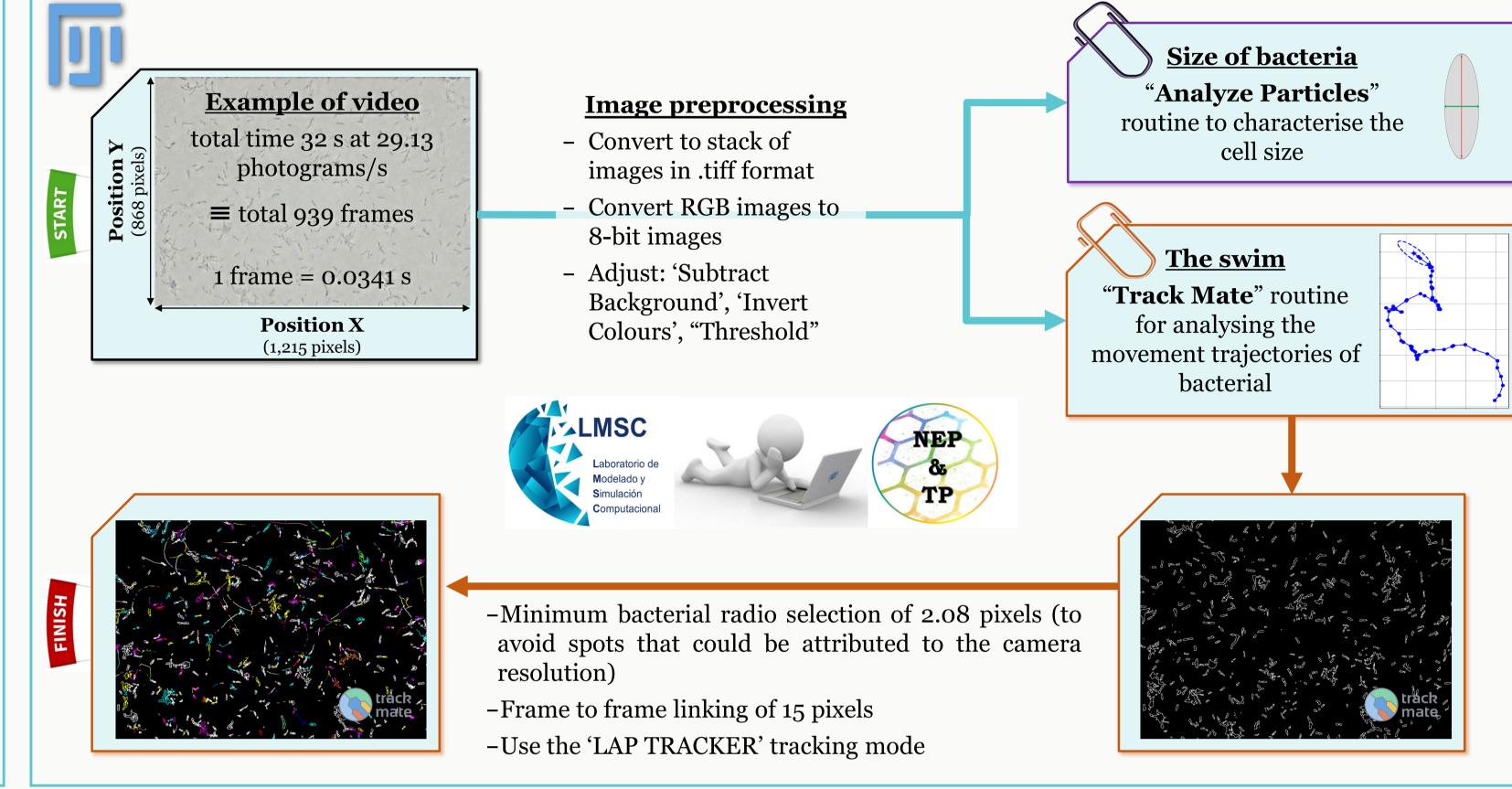
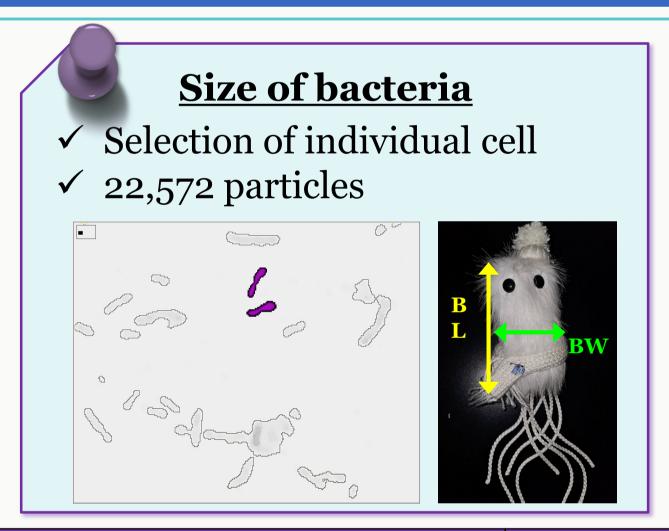


Figure 2. Schematic representation of the digital image analysis procedure with FIJI ®.

RESULTS



Descriptive Parameters	Average
Area (pixels²)	150.3
Length (Feret diameter, pixels)	27.3
Width (MinFeret, pixels)	8.33
Axis Major (pixels)	27.9
Axis Minor (pixels)	6.85
$AR = \frac{\text{Major axis}}{\text{Minor axis}} \qquad \textbf{Aspect Ratio (AR)}$	4.09
$Circularity = \frac{4\pi Area}{Perimeter^2}$ Circularity	0.481
Roundness = $\frac{4Area}{\pi \text{ (Major axis)}^2}$	0.246
Solidity = $\frac{Area}{Canyayaraa}$	0.794

Figure 3. Size and morphological characteristics of P. extremaustralis 2E-UNGS.

GLOSARY

Total Distance: Total particle path (sum of all sections). **Max Distance:** Longest distance between all points on the track. **Confinement Ratio:** Ratio between the net distance travelled and the total distance of the track.

Mean Straight Line Speed: Ratio between the net displacement of the bacterium and the total track time (average speed). Mean Directional Change Rate: Angle between two consecutive

sections of the track, averaged across all sections of the track.

The swim Trajectory study, run or tumble



Filtering details

Of the total number of trajectories, only those occupying between 0.136 and 29.0 s (5 and 850 frames) were considered in order to avoid possible errors in the detection of each track, resulting in a total of 19,150 trajectories to be analysed.

Swimming RUN-type

Within the pool of trajectories, those that are purely run-type swimming were identified and characterised using the 'Mean Straight Line Speed' parameter between 10 and 15 Pixels/Frame, which resulted in the filtering of 44 trajectories.

✓ It was possible to differentiate those with a small angle change rate between each frame using the parameter "Mean Directional Change Rate" between o and 0.1 radians, which resulted in a total of 16 run trajectories.

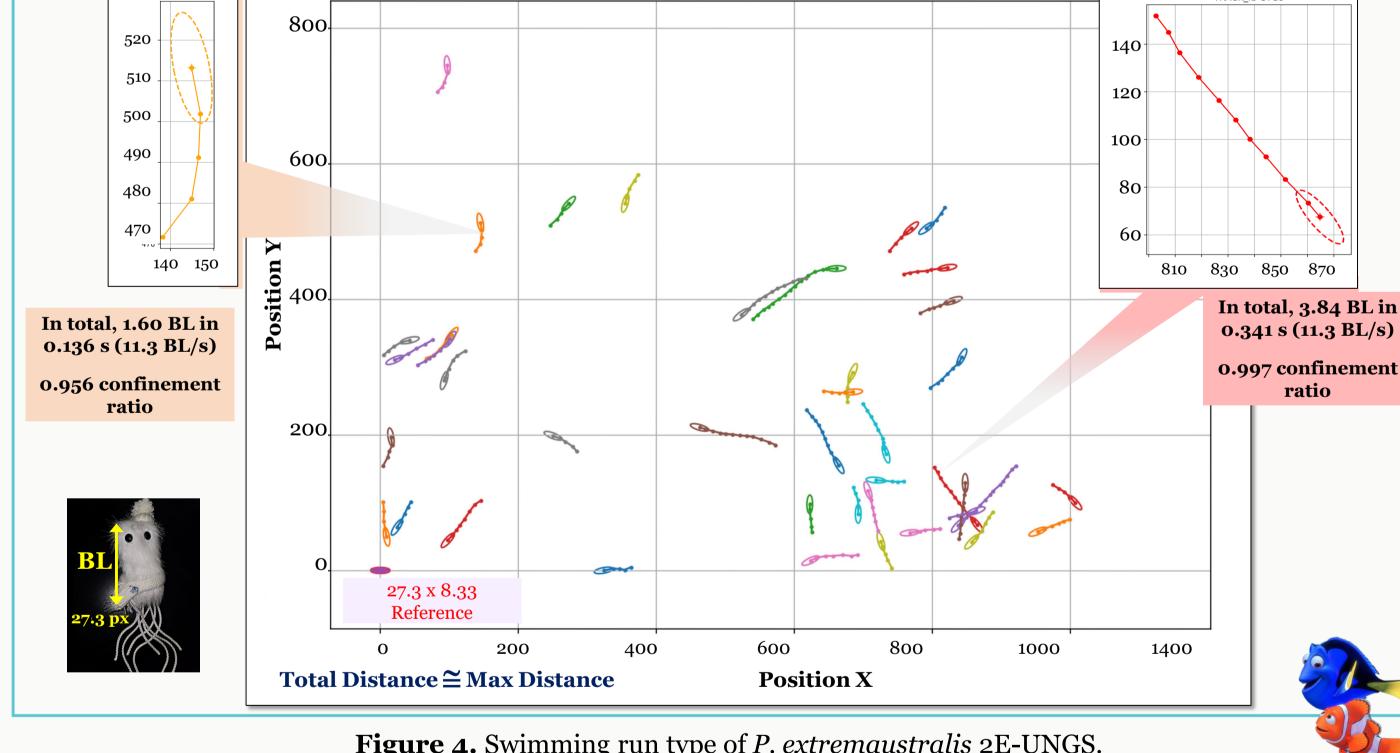
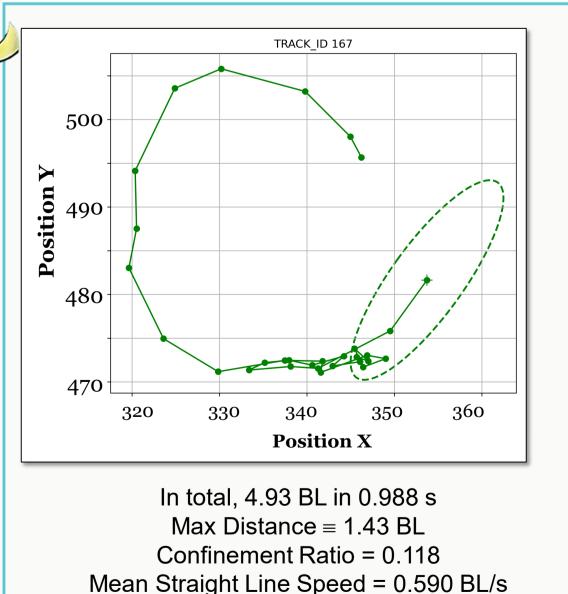


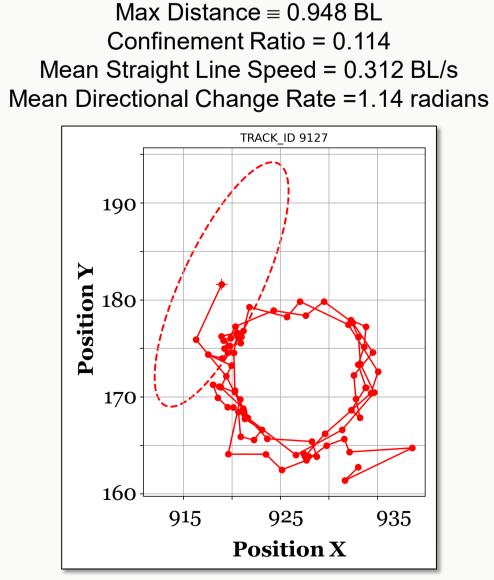
Figure 4. Swimming run type of *P. extremaustralis* 2E-UNGS.

Swimming TUMBLE-type

- It can be observed that the turning radius is proportional to the length of the bacterium.
- Changes in direction in trajectories can be attributed to a collision with another swimmer or even to chemotactic interactions.



Mean Straight Line Speed = 0.590 BL/s Mean Directional Change Rate =1.21 radians



In total, 7.57 BL in 2.76 s

Position X In total, 7.51 BL 1.84 s Max Distance = 2.21 BL Confinement Ratio = 0.277 Mean Straight Line Speed = 1.13 BL/s

Mean Directional Change Rate =1.42 radians

TRACK ID 13902

Figure 5. Trajectories of swimming tumble type of *P. extremaustralis* 2E-UNGS.

CONCLUSIONS



♪ Trajectories with a single type of movement could be identified:

- tumble over small distances with short temporal durations (0.5 s)
- run that covered larger spatial distances with a longer temporal duration (1.7 s).



♪ However, most trajectories showed periods in which these combined swimming styles could be identified.



 ↑ The analysis of digital images using FIJI® and Python® contributed to track individual bacteria for a better understanding of the *P. extremaustralis* 2E-UNGS swimming behaviour.

