Acknowledgements

The authors would like to thank the Royal Geographical Society for providing core funding for this project from the Ralph Brown Award. The University of Ulster and British Institute in Eastern Africa provided additional funds and logistical support. We wish to acknowledge the support of Dave Eastwood, Paul Lane, Ciara Herron, Bernie Lafferty, Rory Quinn and Craig Brown. Additional team support was supplied by Donal and Cian Boland, John Joe McGettigan, John O'Raw and Chris McGonigle. Also the staff of the Zanzibar Antiquities Service and the Institute of Marine Sciences (University of Dar es Salaam).

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Rowing Times from Athens to Mytilene: implications of misreading Thucydides for 5th-century Greek trireme speed

There are only a few sources of data on the speed of the 5th-century Greek trireme derived from reconstruction experiments or analysis of the historical texts. Cotterell and Kamminga (1992: 258) derived theoretical hydrodynamic estimates of the maximum and sustained speeds of 25 km/h (14 knots) and 14 km/h (7.6 knots), respectively. Sea trials of the beautifully constructed experimental trireme *Olympias* demonstrated that 4–5 knots was normal in decent conditions (Morrison *et al.*, 2000: 263). The 2 knots of sustained speed sometimes cited (Olympias, 2015), apply in conditions of adverse headwinds (Lipke, 2012: 15); a 6.8-hour rowing session in strengthening headwind was recorded at 4.6 knots (Morrison *et al.*, 2000: 263). The maximum speed, which is not our concern here, is reported variously as 9 knots (Morrison *et al.*, 2000: 264; Lipke, 2012: 14; Olympias, 2015) or 7.1 knots (Tilley, 2012: 196; Taylor, 2012: 52). Finally, rowing in shifts for 4.5 hours, by rotating an incomplete crew in such a way that each rower was pulling for 40 minutes and resting for 20 minutes, roughly equivalent to half-crew rowing, resulted in a speed of about 3.4 knots (Shaw, 1993: 40).

Estimates may also be inferred from two historical sources. One is by Xenophon (*Anabasis* 6.4.2) who mentions 'a long day's voyage' of 236 km (127 nautical miles) from Byzantium to Heraclea Pontica, which has been interpreted to mean two full-crew rowing sessions of about 8 hours each with a meal break (Morrison, 2000: 103; Wallinga, 2012: 152), yielding an average rowing speed of about 8 knots; however if the 'long day' were interpreted as closer to 24 hours the speed estimate would be lower. The most frequently quoted account (Cotterell and Kamminga, 1992: 257; Harl, 1998;

Table 6. Speed and approximate required power output for the second Athens to Mytilene voyage relative to three assumed normal sustained trireme speeds. Values assume non-stop voyages, with crews rowing and sleeping in turns for the average rowing time per rower of half the voyage duration

Time (h)	Speed (km/h)	Speed (knots)	Speed ratio, second: first voyage	Power factor for half-crew power output at 'normal' speeds		
				8 knots	6 knots	4 knots
24	14.4	7.7	2	2	5	16
48	7.2	3.9	1.5	0.25	0.6	2

Chard, 2007; Pain, 2007; Royce, 2000; Rossiter, 2013) is from Thucydides' *History of the Peloponnesian War* (Crawley, 2004). It describes how during the Mytilene revolt of 427 BC two triremes were dispatched from Athens to Mytilene, a distance of 345 km (185 nautical miles), on successive days. The first was sent with orders to quell harshly the rebellion (*History* 3.36.3) and with crew rowing slowly in light of the orders (3.49.4). The second was sent to countermand the orders and with crew rowing as fast as they could, without stopping, taking turns sleeping, and encouraged by incentives offered by Mytilenian representatives on board (*History* 3.49.3).

Misreading Thucydides

The hydrodynamic calculations and the report by Xenophon according to some interpretations indicate a sustained full-crew speed close to 8 knots for normal rowing shifts. By coincidence, one gets roughly the same value by dividing the distance from Athens to Mytilene by 24 hours: 185 nautical miles/24 hours = 7.7 knots. This is often quoted as the average speed of a trireme achieved in a 24-hour voyage in both scientific and popular literature (Cotterell and Kamminga, 1992: 257; Harl, 1998; Chard, 2007; Pain, 2007; Royce, 2000; Rossiter, 2013). There appear, however, to be two oversights involved. First, according to translations (Crawley, 2004) and re-checked for the present work in the original Greek text, Thucydides does not specify the duration of either of the two Athens-Mytilene runs. Thucydides only states that the second trireme was dispatched the day after the first, probably in the afternoon, following the new decision reached at the Assembly session earlier that day: '… the first ship having about a day and a night's start' (*History* 3.49.3). Second, Thucydides states that the second ship travelled without stopping, that it made an effort to row fast, but that at any given time part of the crew was asleep: 'they took their meals of barley-cakes kneaded with oil and wine as they rowed, and only slept by turns while the others were at the oar' (*History* 3.49.4). The average number of active oarsmen is not specified. Likewise, we are not informed of the duration of the first ship's voyage, except that it was slow as a result of the disincentive of the harsh orders to be carried out: 'the first ship making no haste upon so horrid an errand' (*History* 3.49.5).

Discussion

The coincidental value of 7.7 knots and the reference to the 'next day' are possibly the reasons why Thucydides' *History* is easily misquoted as referring to a one-day Athens-Mytilene voyage (Cotterell and Kamminga, 1992: 257; Harl, 1998), that is to 24 hours, or 'a day and a night' as Greeks would put it—give or take a few hours, which is the reasonable level of accuracy assumed here.

There are secondary considerations. We may dismiss the hypothetical case of a second full crew on board, if possible, as it would imply an overloaded ship with reduced speed. Moreover, the distance between Athens and Mytilene is 50% longer than that between Byzantium and Heraclea Pontica described by Xenophon, implying a declining crew performance with distance and time, reducing the speed, especially if the Athens-Mytilene journey took more than 24 hours. Endurance data associated with sustained speed usually refer to 8-hour shifts (Cotterell and Kamminga, 1992: 259) and may therefore apply to the Byzantium to Heraclea Pontica voyage described by Xenophon, with a rest period between two 8-hour rowing sessions, but less so to the longer Athens to Mytilene voyage. On the other hand, the ambassadors' incentives (*History* 3.49.4) likely worked toward increased speed. In view of assumed level of accuracy and the fact that these effects cancel each other out to some extent, we leave them out of our discussion.

The quadratic law of drag states that upon doubling the speed, the rowing force required roughly quadruples and the rowers' power, which is the rowing force multiplied by the ship's speed, is increased roughly eightfold (Cotterell and Kamminga, 1992: fig. 9.15). Reaching Mytilene in 24 hours, a one-day run, would have necessitated an average speed close to 8 knots (Table 6). For a ship with half crew rowing, and assuming the 'normal' sustained trireme speed was likewise about 8 knots, each person would be required to maintain double normal power output for 12 hours in total. On the other hand if each person maintained normal power in those 12 hours, the speed would drop by the law of drag by 26%, to about 6 knots. There is

no consensus on the 8 knots normal speed; it may well be lower, for example 6 knots. This lower speed would place quintuple relative burden on rowers to reach the 8 knots required for a single-day journey: a factor of 2 as a result of half-crew rowing, and another factor of 2.5 because of the increased drag resulting from increasing the speed from 6 to 8 knots.

Experimental data are driving our estimates of average speed even lower than 6 knots. They are also consistent with the drag law: extrapolating from the 3.4 knots achieved by *Olympias* for half-crew rowing, full crew should reach around 4.3 knots, which falls in the 4–5 knot range cited by Morrison *et al.* (2000: 263). In this case, according to Table 6, even a 48-hour journey would require increased power output by a crew working in two shifts. Table 6 could be extended to other speeds or longer voyages, but for a 72-hour duration all power factors down to 4 knots would be smaller than 1, except if additional unknown factors were introduced, such as adaptive rowing strategies including low-power rowing shifts.

Conclusion

It should be noted when citing Thucydides that he does not explicitly mention the duration of the two Athens–Mytilene runs, and that any statement as to the performance achieved on those runs is based on assumptions derived from speed data obtained from other sources, namely Xenophon and the *Olympias* sea trials.

It remains an open question whether the incentives offered by the Mytilenian ambassadors were sufficient to keep the crew rowing at twice normal power for 12 hours, which would be required to reach Mytilene in 24 hours by rowing and sleeping in shifts by a crew capable of 8 knots normal speed. As there is no consensus on the normal speed, even quintuple or larger power output relative to normal may be required.

If, instead of a one-day run to Mytilene, we invoke the hypothesis of a two-day (48-hour) run, with half of the crew active at any time, rather lower power factors are required. But we are referring to 24 hours of rowing per person, with performance probably decreasing. Furthermore, if crews were not trained for sustained speeds in the 6–8 knots range over such long intervals, but rather for about 4 knots, the possibility of a 48-hour journey may not seem far-fetched, and would come close to the experimental trials of *Olympias* where rowing in turns achieved some 3.4 knots.

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Acknowledgments

Dr Matej Hriberšek of the University of Ljubljana has kindly verified, in sections 49–51 of Book 3 of the original Greek Thucydides' text, that there is no reference to the Athens–Mytilene voyage duration. I am especially indebted to Dr Boris Rankov at Royal Holloway, University of London and rowing master for the *Olympias*, for many discussions of the *Olympias* speed data. Finally, my son Tim's gift of Plutarch's *Lives* spurred comparative reading of sources eventually leading to this work.

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