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Observations on diving behaviour and swimming speeds in a wild juvenile *Tursiops truncatus*

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Abstract

Observations were made on the dive behaviour of a solitary wild juvenile male bottlenose dolphin between March–May 1985 off Pembrokeshire, Wales. Results indicated a mean dive duration of 55.3 sec with an average of 3.5 blows between dives at mean intervals of 10.5 sec. Maximum sustained free-swimming speeds observed declined linearly with duration periods up to 4 min, with observed maximum peak brief effort of 54 km.hr^{-1} over 20 sec. For longer periods, sustained speeds fell between 4–20 km.hr^{-1}.

Introduction

The following observations relate to the wild juvenile male bottlenose dolphin known as 'Simo' who patrolled a narrow stretch of coast off Pembrokeshire, Wales between January 1984 and autumn 1985. These details were presented earlier by Lockyer and Morris (1987). During the period March-June 1985 inclusive, a series of watches from cliff-top vantage points were maintained on the free-ranging dolphin. Observations on swimming, diving, feeding and respiratory behaviour were made. Additional behavioural observations were made from boats, both by ourselves and local fishermen.

Methods

Diving and respiratory behaviour

A series of different watches on dive behaviour were recorded, and categorized broadly according to the primary activity. These were 1) *fishing*, when the dolphin was observed diving in a confined area usually around a rock between Dinas Fach and Pen Dinas (51°51.5′N, 5°9′–10.5′W) with no surface activity except for blowing, 2) *swim-migratory*, when the dolphin was observed moving purposefully from one location to another over a considerable distance e.g. across a bay, usually with frequent jumping clear of the water, and 3) *swim and fishing*, when the dolphin appeared repeatedly to make exploratory dives and then move short distances. Only dives when no external human interference was present were recorded. The dive duration, defined broadly as a period underwater lasting 20 sec minimum, number of blows between dives, and interval between blows (excluding dives) were recorded using a stopwatch and cassette-tape recorder or simple note-taking. The date, time of day and tidal state were also recorded.

Sustained swimming speeds

Observations were made from cliff-top vantage points when direction and distances covered by the dolphin could be accurately assessed from detailed charts, and speeds could subsequently be calculated from stopwatch recordings. Observations were also made by experimentally inducing the dolphin to follow an inflatable with outboard engine, which was driven at sufficiently high speeds to keep well ahead of the dolphin and avoid both the effects of bow-riding and wake slip-streaming which would bias swim-speeds. The boat was motored between set points on the coast (compass bearings being taken) in a direct line, at slack water, so that both distance (from charts) and time (from stopwatch) could provide an accurate assessment of speed. Usually the dolphin appeared to participate readily in this experiment, the only inducement required being that the boat (and coxs'n) be well familiar to the dolphin. The main constraints on this exercise were weather and sea states, and suitable location, although the dolphin could be led to such a location.

Results

Diving and respiratory behaviour

Overall, 9 dive series recorded, each series lasting between 7–60 min. Dive series in all three categories

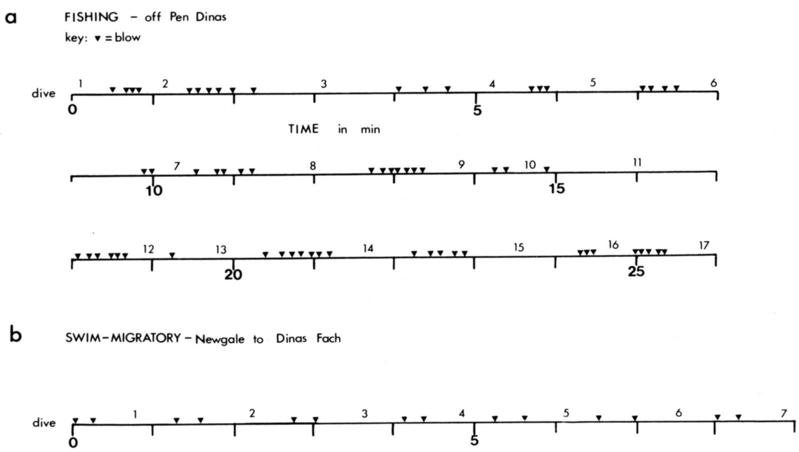

Figure 1. Dive and respiratory sequences for 'Simo', showing:
a) *Fishing* behaviour (series reference 2) on 27 March 1985, Commencing at 11.10 hr, and
b) *Swim-migratory* behaviour (series reference 5) on 17 April 1985, commencing at 10.40 hr.

were recorded, and Fig. 1 illustrates examples of *fishing* and *swim-migratory* categories. In general, the former appears to be characterized more by variable dive period and blow rate, the latter being rather more regular in pattern. It was noted that whilst all observations were made between approximately 10.00 and 18.00 hr when lighting was good, the *fishing* dives were all observed mid-way between high and low water tides, similar to findings for another bottlenosed dolphin (Lockyer and Morris, 1986), and were also between 11.00–14.30 hr.

Fig. 2 shows the frequency distributions of the three dive parameters (dive duration, blow count and blow interval) for all 136 dives recorded regardless of category. All three distributions are skewed from normal (and we would expect this for dive duration because the cut-off point has already been set at 20 sec). The modal values of dive duration fall in the range 25–35 sec, number of blows in the range 1–3, and blow interval 9–11 sec.

In an analysis of data, mean dive durations, number of blows between dives and blow intervals were calculated and are presented in Table 1. The data demonstrate considerable overlap between categories in each of these three parameters, with notable exceptions in series 3 dive duration, and blow interval in series 5 and 6. These observations however, merely support the general pattern shown in Fig. 1. In general there were no consistent differences between the three categories of dive series, and overall means of the three dive parameters using the data from the 9 dive series are given in Table 1. The 95% confidence intervals (C.I.) for these means are 50.41–60.23 sec dives duration, 3.14–3.86 blows between dives, and 9.67–11.25 sec interval between blows.

Occasionally there were significant correlations between number of blows and dive duration, where sample size was adequate for testing, such as series 1, with probability $p<0.01$, correlation coefficient $r=0.561$, degrees of freedom d.f. $=22$, and series 3 with $P<0.05$, $r=0.410$, d.f. $=23$; both series are of the *fishing* category. When all dive data were combined, there was a significant correlation between dive duration and blow count with $P<0.01$, $r=0.279$, d.f. $=134$. There was also a significant correlation between blowing interval and dive duration with $P<0.02$, $r=-0.236$, d.f. $=104$. The total blowing period (**b** in sec) was directly correlated with the blow count (c), with $P<0.001$, $r=0.927$, d.f. $=104$. A least-squares linear regression analysis gave the relationship—

1 $$\mathbf{b}=9.399c-8.005$$

where s.d. values were 0.329 and 1.346 respectively. However, there was also a significant negative correlation between blow interval and blow count with $P<0.05$, $r=-0.225$, d.f. $=104$. The plot of blow interval against blow count is shown in Fig. 3 and indicates a minimum blow interval of about 5 sec that does not appear to reduce further with number of blows.

Sustained swimming speed

A total of 12 observations were made for different durations between 20 sec and 20 min. These data are plotted in Fig. 4. A significant correlation was found between speed and duration for all data with

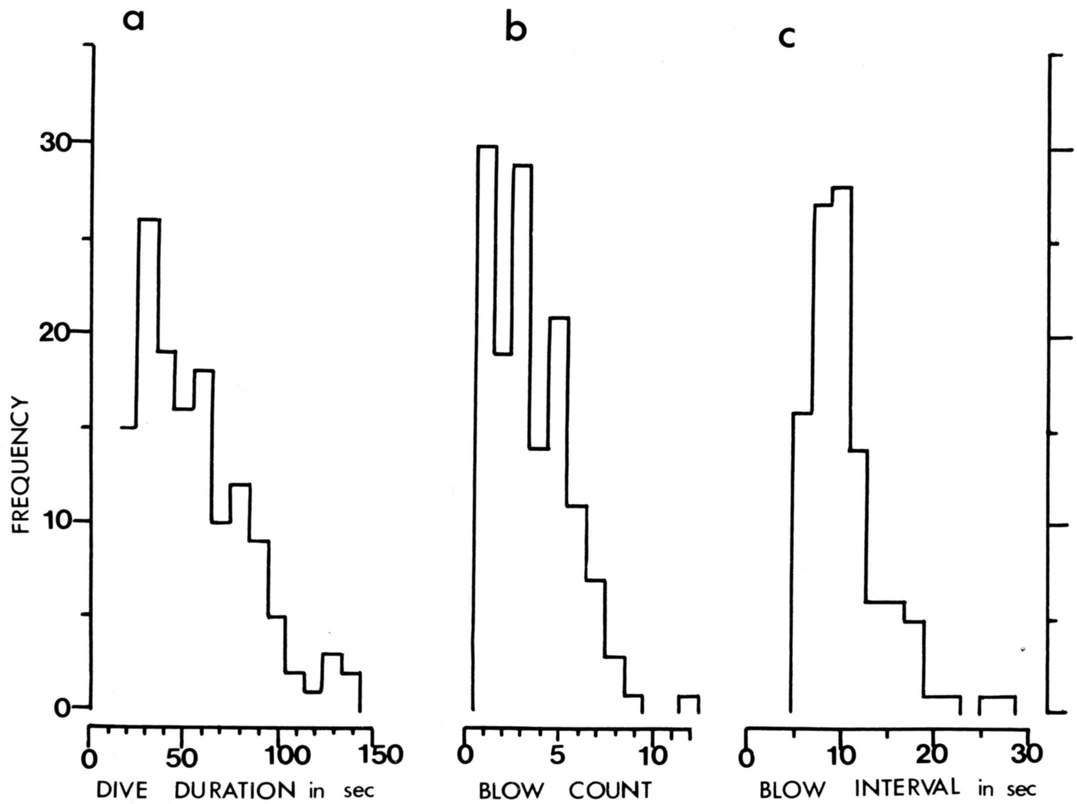

Figure 2. Frequency distribution histograms for all dive data for dive parameters a) duration (sec), b) number of blows between dives, and c) interval between blows (sec), for 'Simo'.

Table 1. Mean dive parameters for 'Simo', giving mean and s.d.

Series reference	Number of dives in series	Category of behaviour	Dive duration (sec) mean	Dive duration (sec) s.d.	Number of blows mean	Number of blows s.d.	Blow interval (sec) mean	Blow interval (sec) s.d.
1	24	fishing	61.7	29.7	3.0	1.7	10.7	3.7
2	24	fishing	69.3	27.2	4.1	1.9	7.5	1.9
3	25	fishing	34.7	14.6	2.8	1.7	11.6	4.3
4	27	fishing	50.8	26.8	4.0	2.0	9.3	2.2
5	6	swim–migratory	60.5	5.9	2.0	0.0	18.8	4.9
6	5		59.6	32.4	3.6	1.7	16.0	3.7
7	9		67.2	47.3	3.9	3.3	8.2	2.0
8	9	swim and fishing	53.3	31.1	2.2	1.6	9.6	2.4
9	7		62.6	31.0	5.9	3.3	10.2	1.9
All 1–9	136	All types	55.3	28.9	3.5	2.1	10.5	4.1

$P<0{\cdot}05$, $r=0{\cdot}576$, d.f. $=10$. Analysing only data up to a total duration of 4 min, a significant correlation was found between speed (**s**) and duration (**t**) with $P<0{\cdot}01$, $r=0{\cdot}952$, d.f. $=4$. The linear least squares regression of these data gave a declining slope—

$$\mathbf{s}=57.162-11.807\,\mathbf{t} \qquad 2$$

where **s** is in $km.hr^{-1}$ and **t** is in min; s.d. values were 4.463 and 1.688 respectively. The slower fall-off in sustained speed after this 4 min period, showed an

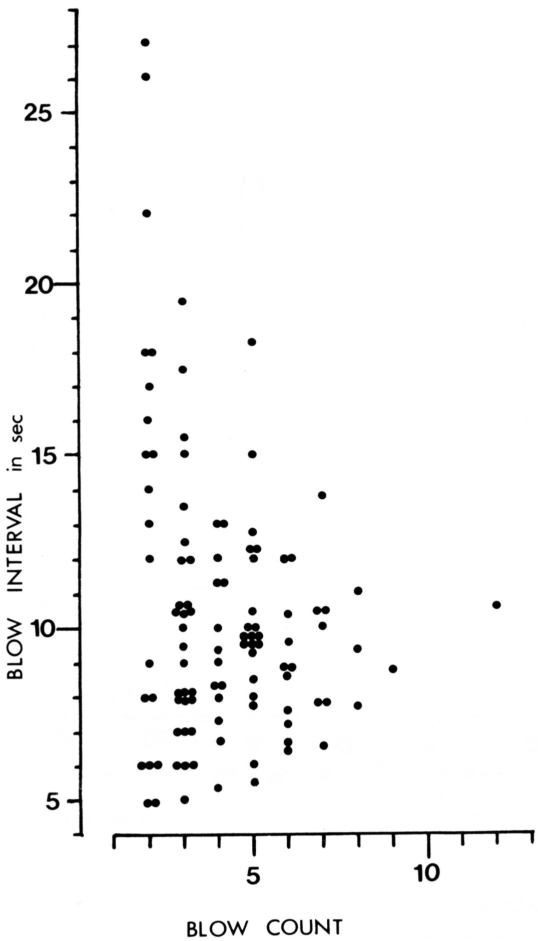

Figure 3. Relationship between blow interval and number of blows for all dive data for 'Simo'.

ultimate levelling off with variable values between 4–20 km.hr^{-1}, perhaps averaging 10–15 km.hr^{-1}. Whilst speeds of 20 km.hr^{-1} could be sustained for 6 min and 10 km.hr^{-1} for 7.8 min, the speed of 54 km.hr^{-1} could be only substained for 20 sec, representing peak brief effort.

Discussions and conclusions

The diving and respiratory data have similarities with those recorced for 'Percy', a solitary adult male bottlenosed dolphin (Lockyer and Morris, 1986). For 'Percy', the dive durations, number of blows and blow intervals were 112 ± 21 sec, 2.6 ± 0.5 blows, 11 ± 2 sec for series 1, and 61 ± 18 sec, 2.6 ± 1.0 blows, 15 ± 5 sec for series 2.

Wursig, Cipriano and Webber (1985) recorded a mean dive duration of 18.7 ± 19.46 sec ($n = 6077$) with a range of 2–182 sec for wild *Lagenorhynchus obscurus* off New Zealand. They included all underwater sequences in the dive definition. The mean blow rate was thus approximately 3.2 blows.min^{-1}. Leatherwood and Ljungblad (1979) recorded dive behaviour for a wild *Stenella attenuata*, and categorized dives according to *feeding*, *running* and *travelling* or *exploratory diving*. Dive durations averaged 15–31.6 sec but could last 204 sec. Fig. 2 shows that 'Simo' dived for periods of up to ca 140 sec. Leatherwood and Ljungblad observed that during *feeding* mode long dives were interrupted by groups of rapid blows. For 'Simo', dive duration and blow count were correlated.

The finding that blow interval does not appear to reduce beyond a certain level (Fig. 3), suggests that there may be a critical blow interval which is controlled by anatomical, physical or physiological constraints to prevent more rapid blowing. This would be in line with the observations of Lockyer (1977) for diving sperm whales (*Physeter macrocephalus*), where it was found that blowing rate remained fairly constant even after long dives, but that total time spent blowing, and hence total number of blows were increased. The findings for 'Simo' that dive duration was correlated with blow count, and that total blowing interval was directly related to blow count are thus similar to the results for sperm whales. Parry (1978) found that the usual blow interval in captive *T. truncatus* was 6–12 sec, which encompasses the mean blow interval observed here (see also Fig. 2). Parry observed a single blow interval of only 3.2 sec, although over half of her observations exceeded 12 sec. She also found that the actual blow duration usually lasted only 0.8–1.0 sec, a mere fraction of the respiratory cycle.

We may conclude therefore that generally, the longer the dive, the longer the total period of blowing and also the greater number of blows, with a threshold of a minimum blow interval of 5 sec regardless of increase in other dive parameters. It is worth noting here that blowing did not necessarily occur each time the dolphin's head broke the surface although this was usually the pattern.

The speed observations over long duration are well within the range reported for bottlenosed dolphin e.g. 7 km.hr^{-1} while feeding (Shane, 1986; Tayler and Saayman, 1972). Average speeds sustained for an hour of 10.7 knots (ca 20 km.hr^{-1}) for *S. attenuata* (Leatherwood and Ljungblad, 1979), and up to 18 km.hr^{-1} for *S. longirostris* (Au and Weihs, 1980) have been reported. Lockyer (1978) reported that 'Beaky', a solitary wild adult male bottlenosed dolphin (length 3.6 m), maintained a speed of 15–20 knots (ca 28–37 km.hr^{-1}) over a mile distance, representing a sustained speed for 2.5–3.4 min. From Fig. 4 and formula 2, such a sustained speed is just feasible for the smaller 'Simo' at a predicted speed of

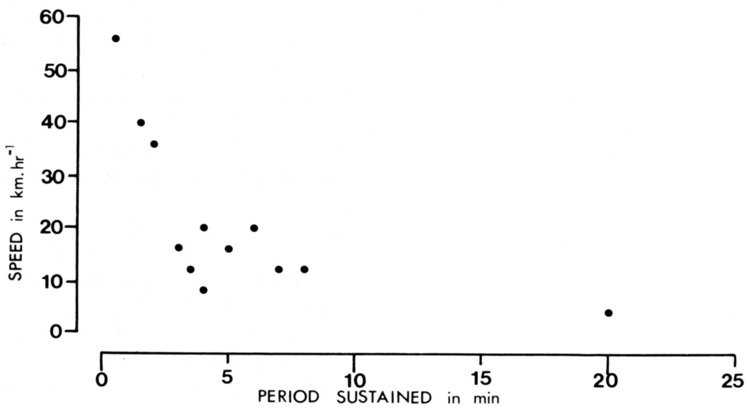

Figure 4. Relationship between observed swimming speed (km.hr^{-1}) and period sustained (min) for 'Simo'.

17–28 km.hr^{-1}, but this must represent the upper limit.

Au and Weihs (1980) reported that leaping occurred in *S. longirostris* when *running* (swimming fast on alarm) and seemed to be related to energy saving with extra speed. Certainly 'Simo' frequently jumped clear during *swim-migratory* behaviour, but not during *fishing* and *swim and fishing*. The rapid fall-off in sustained speed in Fig. 4 from brief peak effort at 54 km.hr^{-1}, is probably a fair representation of the physiological limitation on sustained effort.

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References

Au, D. and Weihs, D. (1980). At high speeds dolphins save energy by leaping. *Nature, Lond.* 284(5756): 548–550.

Leatherwood, S. and Ljungblad, D. K. (1979). Nightmare swimming and diving behavior of a radio-tagged spotted dolphin, *Stenella attenuata*. *Cetology* 34:1–6.

Lockyer, C. (1977). Observations on diving behaviour of the sperm whale *Physter catodon*. In, Angel, M. (ed.) *A voyage of Discovery*, pp. 591–609, Pergamon Press, 696 pp.

Lockyer, C. (1978). The history and behaviour of a solitary wild, but sociable, bottlenose dolphin (*Tursiops truncatus*) on the west coast of England and Wales. *J. nat. Hist.* 12: 513–28.

Lockyer, C. and Morris, R. J. (1986). The history and behaviour of a wild, sociable bottlenose dolphin (*Tursiops truncatus*) off the north coast of Cornwall. *Aquatic Mammals* 12(1): 3–16.

Lockyer, C. and Morris, R. J. (1987). Observed growth rate in a wild juvenile *Tursiops truncatus*. *Aquatic Mammals* 13(1): 27–30.

Parry, K. (1978). *The functional anatomy of the odontocete nose and snout*. Ph.D Thesis accepted by the University of Cambridge, England.

Shane, S. H., Wells, R. S. and Wursig, B. (1986). Ecology, behavior and social organization of the bottlenose dolphin: a review. *Mar. Mamm. Science* 2(1): 34–63.

Tayler, C. K. and Saayman, G. S. (1972). The social organization and behaviour of dolphins (*Tursiops aduncas*) and baboons (*Papio ursinus*): some comparisons and assessments. *Ann. Cape Prov. Mus. (nat. Hist.)* 9: 11–31.

Wursig, B., Cipriano, F. and Webber, M. (1985). Movement and dive patterns of radio-tagged dusky dolphins (*Lagenorhynchus obscurus*) in New Zealand. *Sixth Biennial Conference on the Biology of Marine Mammals* (Society for Marine Mammology Abstract), Vancouver Aquarium, Canada, 22–26 November 1985.