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Preliminary, qualitative observations indicated that the dolphins were not evenly distributed along the rivers but were to be found in greater densities around the mouths of streams and canals intersecting the river and in places of increased turbulence. Also it appeared that the two species had different group sizes, *Sotalia* being commonly encountered in groups of two, three or more and *Inia* generally being found singly. The survey was designed to address the following questions: 1. Are numbers of dolphins affected by the presence of tributaries or areas of turbulence? 2. Do group sizes of the two species differ and are they affected by these same factors? 3. What is the present density of dolphins in terms of numbers seen per kilometer of survey? 4. Are the distributions of the dolphins consistent with their being strongly territorial?

The authors are engaged in a study of the Amazonian manatee under the auspices of the Brazilian Instituto Nacional de Pesquisas da Amazônia (INPA) which necessitates extensive boat travel on many of the rivers of Brazilian Amazonia. We took this opportunity to gather the data on Amazonian dolphins reported here.

At present both species are considered abundant in Brazilian waters. However, with increasing habitat destruction and fishing pressures in the Amazon the numbers of dolphins cannot be expected to remain stable (Nature Conservancy Council, 1979) and it has even been proposed that the dolphin populations be reduced to increase the fishing potential of the region (MESCHKAT, 1961). It is important that baseline studies be undertaken now so that the effects of potentially harmful changes can be assessed.

The only detailed field observations on Amazonian dolphins are those of PILLERI and ARVY, 1977. The only detailed field observations on Amazonian dolphins are those of PILLERI and ARVY, 1977. The only detailed field observations on Amazonian dolphins are those of PILLERI and ARVY, 1977.

Two species of dolphin, *Inia geoffrensis* and *Sotalia fl. fluvialis* occur in the waters of the Amazon River and its tributaries (CABRERA, 1940; HERSHKOVITZ, 1963). The former belongs to the Platanistidae, a family of dolphins widely distributed in coastal waters and larger freshwater rivers and lakes of South America, India and China. They are considered to be morphologically primitive. The latter belongs to the widespread, morphologically advanced and predominantly marine group, the Delphinidae. These two species both occupy similar ranges.

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NUMBERS AND BEHAVIOUR OF AMAZONIAN DOLPHINS, *INIA GEOFFRENSIS* AND *SOTALIA FLUVIALIS*, IN THE RIO SOLIMÕES, BRASIL*

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manus manatus) from

May, 1975. Intern. Zoo

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- 50 kg
- 46 kg
- 41 kg
- 36 kg
- 34 kg
- 31 kg
- 28kg

weight

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Introduction

The survey was carried out on the Rio Solimões between Manaus and Jutica, a distance of approximately 550 km by river. The river is the major "white water" (water discolored by silt, visibility a few centimetres or less) tributary of the Amazon and is large, up to 5 km in width, and contains many islands. In many places small channels (paraná) and streams enter the main river. In this survey these different types of intersections were not differentiated but were all designated as tributaries whether they represented affluents or effluents. No attempt was made to standardise the position of the boat relative to the bank. The course taken was that considered by the captain to be the most expedient for travel, generally within 30 m of a bank of the river or one of the many large islands. At the time of the survey, 18-21 August 1979, the river was about a third of the way through the seasonal decline of about 10 m.

Except for the first day a continuous watch was kept for dolphins while the boat was travelling and the time of sighting and number of individuals in each group of dolphins were recorded. Whether the dolphins were near the mouth of a tributary or in an area of turbulence was noted. The location, weather conditions, and approximate distance covered on each day of survey are given below.

18 August. Surveys were conducted between 0700 and 0900, 1030 and 1130, 1230 and 1330, 1600 and 1800. The weather was bright and sunny with little wind. Approximately 100 km of river was traversed between Manaus and a point on the river approximately 25 km upstream of Manacapuru.

19 August. Surveys were continuous from 0600 to 1700, the weather was overcast with frequent wind and rain. Approximately 150 km of river was traversed starting at the point the previous survey finished and extending to the town of Codajás.

20 August. Surveys were undertaken from 0700 to 1900. The weather was bright and sunny. Approximately 140 km of river was covered between Codajás and Coari.

21 August. Surveys were undertaken between 0600 and 1800. The weather was bright and sunny. Approximately 150 km of river was traversed starting at Coari and ending at a point in the vicinity of Jutica, about 50 km downstream of Tefe.

On 20 August and 21 August data also were taken on the relative availability of the following habitat features: 1. The presence of the mouth of a tributary during each 10 min of travel. 2. The turbulence of the river at the beginning of each 10 min interval. Turbulence was measured on a four point scale:

0. - No noticeable water movement. Such areas generally were restricted to wide sandy sections of rivers;

1. - Normal turbulence, ripples and water movement being visible but causing only small surface disturbances;

2. - Considerable surface movement obvious but with no noticeable effect on stability of the boat;

3. - Sufficient turbulence to affect the stability and direction of the boat, an 18 m wooden vessel powered by a 16 horsepower diesel motor.

Analyses. To test whether dolphins were distributed randomly along the rivers the distribution of numbers of groups in each 2 km was compared to a Poisson of equal mean (ZAR, 1974). A property of the Poisson distribution is that the mean equals the variance. If the distribution is more clumped than expected the mean will be small relative to the variance, if more uniform than expected the mean will be large relative to the variance. A simple test of this relationship is the sum of squares divided by the mean which is distributed as chi squared with $n-1$ degrees of freedom (STEELE and TORRIE, 1960).

Effects of tributaries and turbulence were analysed by contingency table analysis (ZAR, 1974). Although outflows of tributaries are sometimes turbulent there was no significant association between classes of turbulence and the presence of outflows ($X^2 = 5.29, 0.25 > P > 0.1$), hence the effects of each were analysed separately. The analyses compare the ratios of numbers of

dolphins found associated with each level of a habitat feature (presence or absence for tributaries, scale 0 - 3 for turbulence) to the ratios of numbers of sections of river with each of these levels. Numbers of sections of river with each level being our measure of availability. In cases where insufficient numbers were represented in a level, the level was combined with the next lowest on the scale for analysis.

Results

Approximately 490 km of river were surveyed and 291 individuals of *Sotalia* (135 groups) and 107 individuals of *Inia* (78 groups) encountered. These are the numbers used for observed density and group size analyses. Analyses of habitat preferences are based on the third and fourth days of survey when 180 individuals (75 groups) of *Sotalia* and 58 individuals (48 groups) of *Inia* were sighted.

The number of individuals encountered per km of survey was 0.59 for *Sotalia* and 0.22 for *Inia*. However, as we suspect there may be diel variations in sightability of dolphins it probably is best to use only those days for which the survey was more or less continuous from daylight to dusk. For the same reason, it probably is not valid to give an estimate of the standard deviation based on each kilometer surveyed, but the standard deviation of the mean based on each full day of survey is a useful statistic for comparisons with other, similar, surveys. Discarding the first, partial, day of survey we get a mean number per km of survey \pm standard deviation of 0.53 ± 0.21 for *Sotalia* and 0.19 ± 0.06 for *Inia*.

Counts of group size are made difficult by the problems of identifying individuals. Group sizes, especially of *Sotalia*. Large numbers of animals surfacing in close proximity, especially if not surfacing synchronously, can be misleading. We recorded only the lesser number under such circumstances and therefore our counts generally should be regarded as minima. The distributions of group sizes of *Inia* and *Sotalia* (Fig. 1) differed significantly (KOLMOGOROV-SMIRNOFF test, $0.78135 = 0.36$, $P < 0.001$). The majority of *Inia* (81 percent) were solitary whereas the majority of *Sotalia* (55 percent) were in groups of two or more.

The number of groups of *Sotalia* at mouths of tributaries approached the significance level ($X^2_1 = 3.44$, $P < 0.05$) and the portions of groups of *Inia* at these locations approached the significance level ($X^2_1 = 3.44$, $P < 0.05$). However, group sizes were not significantly larger at mouths of tributaries for *Inia* or *Sotalia* ($X^2_1 = 0.44$, $0.5 < P < 0.75$ and $X^2_3 = 4.67$, $0.1 < P < 0.25$ respectively). There was no significant relationship between group sizes and turbulence for *Sotalia* ($X^2_2 = 1.66$, $0.25 < P < 0.5$). The ratio of groups of *Inia* with one member to those with two or more in turbulence categories 0 and 1 (7:5) is sufficiently different to the ratio of group sizes in turbulence categories 2 and 3 (48:11) to suggest that the lack of significance ($X^2_1 = 3.41$, $0.05 < P < 0.1$) might be due to the small sample size in the more turbulent water.

The number of groups of *Inia* in each category of turbulence was not significantly different to that expected from the ratios of numbers of sections of river with each of these categories ($X^2_3 = 2.78$, $0.25 < P < 0.5$). The number of groups of *Sotalia* in turbulence 0, turbulence 1 and turbulence 2 + 3 was significantly different to the proportions of sections of river with each of these turbulences ($X^2_2 = 6.88$, $0.025 < P < 0.05$). However, when turbulence one was dropped from the analysis there was no significant difference between the remaining categories ($X^2_2 = 0.23$, $0.5 < P < 0.75$), suggesting that the significant difference resulted from the greater proportion of animals in turbulence 1.

The distribution of groups of *Sotalia* was more clumped than expected under a hypothesis of random (Poisson) distribution ($X^2_{229} = 284.0$, $0.005 < P < 0.01$). However, the distribution of groups of *Inia* did not differ significantly from random ($X^2_{229} = 250.9$, $0.1 < P < 0.25$).

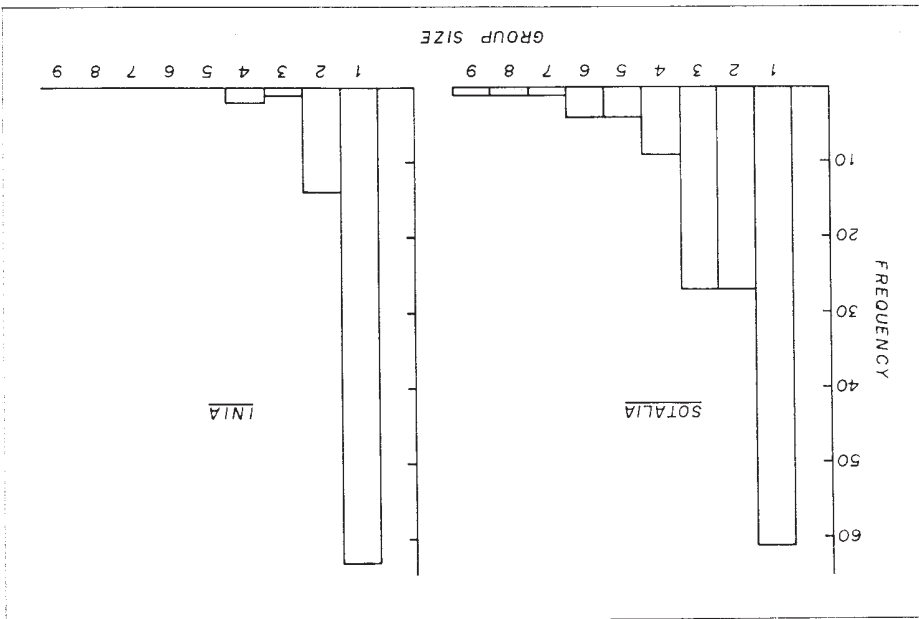
of *Inia* were sighted.
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It is unlikely that it would be feasible to calculate the absolute density of dolphins in the Amazon without expensive surveys and the utility of doing so is debatable. Our survey was designed only to give an index of present population levels. It should be sufficiently reproducible, even given different observers, to allow monitoring of gross fluctuations in population levels. The survey was carried out on days of very different weather conditions and over large stretches of river so the standard deviations are probably representative of those likely to be encountered. We suspect that there could be diel variations in sightability, due to variations in the behaviour of dolphins (SAAYMAN et al., 1973; WATERMAN, 1967) or due to glare, that we could not separate from other factors during this survey. Therefore, we recommend that these results be compared only with surveys carried out from dawn to dusk and over similar distances. In addition, the behaviour of many aquatic animals of the region, including dolphins, is known to be strongly seasonal (GOULDING, 1978; PILLERI, 1969), so surveys carried out during other seasons may not be comparable.

The area surveyed is typical of the "white water" sections of the Amazon and its tributaries. There are three other major habitats within the Amazon basin in which dolphins occur but which may differ in their suitability for dolphins. The "black water" rivers (water with little suspended matter but discoloured by organic acids) such as the Rio Negro, "clear water" rivers (water without high concentrations of organic acids and carrying only moderate loads of suspended matter, visibility usually a metre or more) such as the Rio Tapajos, and the system of lakes and interconnecting paranas (these may contain "white water", "black water", "clear water" or a mixture) that border the rivers. We commenced a survey of the latter, covering approximately 100 km at the conclusion of the survey reported here. The preliminary results indicate that there is such great variability between individual lakes and sections of paranas that it will take thousands more kilometres of survey to determine what is representative of these areas. Further surveys will be made as opportunities present themselves.

Discussion

Fig. 1 Frequency distributions of group sizes of *Inia* and *Sotalia* in the Rio Solimões, Brasil.



Results of surveys of amazonian dolphins, *Inia geoffrensis* and *Sotalia fluviatilis*, in the Rio Solimões Brasil, are presented. Details of survey methods are given so that the results can be compared with future surveys to detect gross changes in dolphin numbers. The majority of *Inia* encountered (81 percent) were solitary whereas the majority of *Sotalia* (55 percent) were in groups of two or more. Numbers of groups of *Inia* were unaffected by the turbulence of the river but the data suggest that *Sotalia* avoids areas of very high and very low turbulence. *Sotalia* and possibly *Inia* congregate at the junctions of the river and streams and canals. The spacing of groups along the river was random for *Inia* and clumped for *Sotalia*. Therefore spacing cannot be used as evidence that either species is territorial.

Summary

between dolphins. others, have rarely observed behaviour that could be interpreted as territorial interactions aggregations of dolphins at tributaries and around stationary boats we, and to our knowledge VAN BREE (1974). However, it is consistent with the fact that at large and probably artificial This is not consistent with the impressions of PILLERI and GHR (1977) or TREBBALU and around resources. If *Inia* have distinct home ranges they are apparently large and overlapping that groups are neither evenly distributed, which might suggest territoriality, nor clumping turbulence. However, the distribution of groups of *Inia* did not differ from random, indicating by chance, possibly as a result of this species apparent preference for water of a particular The distribution of groups of *Sotalia* along the river was more clumped than would be expected more specialized *Sotalia* is less adaptable to the variety of conditions encountered in the river. lack turbulence. It is possible that this results from a difference in food preferences or that the considered normal for the river as opposed to areas of high turbulence and areas that appear to all degrees of turbulence. *Sotalia* show distinct preferences for areas of turbulence that can be (1974) that *Inia* prefers still waters, groups of *Inia* in the Rio Solimões appear to utilize areas of In contrast to the observations of PILLERI and GHR (1977) and TREBBALU and VAN BREE increased turbulence.

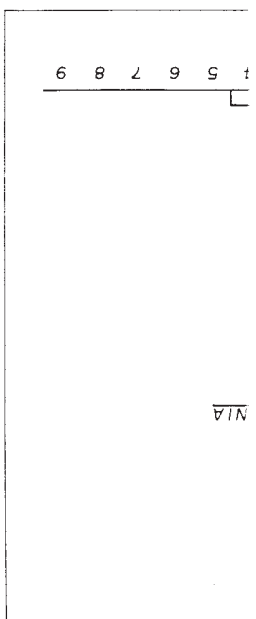
It is our subjective opinion that a larger sample size could show that *Inia* congregate at areas of However, the small sample size does not inspire confidence in a similar decision regarding *Inia*. From the data there can be little doubt that turbulence has no effect on group sizes of *Sotalia*. Amazonian dolphins which hopefully will shed light on this aspect.

One of us (V.M.F. DA SILVA) is presently engaged in a study of the feeding ecology of likely explanation for this is that food is more abundant or more available at these locations. junctions of tributaries appear to be important for *Sotalia* and possibly also for *Inia*. The most likely that the counts of group sizes of *Inia* greatly underestimate the true situation. contrast most *Inia* are easily distinguishable by colour, size and method of surfacing. It is un distinguishable only on size and when not surfacing synchronously are easily confused. In containing only one individual is almost certainly an overestimate as individuals are generally LAYNE (1958) observed similar behaviour in Colombia. The proportion of groups of *Sotalia* basic result that *Inia* is principally solitary and *Sotalia* usually occurs in groups of two or more. It is difficult to make accurate counts of group sizes of dolphins but we are confident of the fish in the Amazon. densities for large carnivorous mammals, possibly reflecting the abundance and diversity of individuals of *Sotalia* and 0.4 individuals of *Inia* per kilometer of river. Surprisingly high and possibly is many times greater. Taking a minimum estimate as twice what we saw gives 1.0 probably is at least twice what we saw, as we generally were surveying only close to one bank. While not presenting our results as absolute density, the actual density per kilometer of river

mazon and its tributaries. which dolphins occur but rivers (water with little sus- Negro, "clear water" rivers only moderate loads of sus- Tapajos, and the system of "er", "black water", "clear re. The preliminary results s and sections of paranas : what is representative of emselves.

99), so surveys carried out region, including dolphins, to dusk and over similar fore, we recommend that (1967) or due to glare, that ability, due to variations in ative of those likely to be conditions and over large fluctuations in population could be sufficiently repro- ebatable. Our survey was density of dolphins in the

o Rio Solimões, Brasil.



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