Editorial Comment. – This section has been established as a forum for the exchange of ideas, opinions, position statements, policy recommendations, and other reviews regarding turtle-related matters. Commentaries and points of view represent the personal opinions of the authors, and are peer-reviewed only to the extent necessary to help authors avoid clear errors or obvious misrepresentations or to improve the clarity of their submission, while allowing them the freedom to express opinions or conclusions that may be at significant variance with those of other authorities. We hope that controversial opinions expressed in this section will be counterbalanced by responsible replies from other specialists, and we encourage a productive dialogue in print between the interested parties. Shorter position statements, policy recommendations, book reviews, obituaries, and other reports are reviewed only by the editorial staff. The editors reserve the right to reject any submissions that do not meet clear standards of scientific professionalism.

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Manipulating Sex Ratios: Turtle Speed Ahead!

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Vogt's (1994) commentary in this journal draws attention to the need for more awareness of the scientific literature on sex ratios by those managing sea turtle populations. In particular, he proposes more use of artificial incubation of turtle eggs for two reasons: first, to avoid incubation near the pivotal [= threshold] temperature (the constant temperature giving 50% of each sex) and thereby reduce the numbers of intersexes, and second, to produce female-biased sex ratios to boost population levels. Few would dispute that the influence of incubation temperature on sexual differentiation has implications for conservation practices. Unfortunately, however, the data base is not as solid as one might wish; on a number of points there is frank disagreement.

Fundamental to any scientific assessment of the influence of temperature on sex ratio is a reliable method of sexing. The method of soaking gonads in glycerine to render them transparent and make internal structures visible (van der Heiden et al., 1985) is a clever idea and evidently works in some circumstances for some species. For sea turtles, however, the method has not been adequately validated, and there are two published reports of failure to validate this technique (Jackson et al., 1987; Mrosovsky and Benabib, 1990). Vogt indicates that one of these validation attempts (Mrosovsky and Benabib, 1990) was flawed because gonads were not preserved properly. But the authors of that study noted that "histology carried out on the gonad from one side of each turtle confirmed that fixation had been good." According to van der Heiden et al. (1985), the method works on fixed tissue; no qualifications about fixation methods were given by these authors. On a personal note, from a laboratory that has contributed to three papers on methods of sexing turtles (Yntema and Mrosovsky, 1980; Whitmore et al., 1985; Mrosovsky and Benabib, 1990), we add that we had ardently hoped to be able to use the glycerine method: it would have saved much time and effort.

These are not mere academic arguments about technical details of fixation or morphology. They have management implications. For instance, using the glycerine method in a study on the west coast of Mexico, Benabib (1984) reported that 14% of her sample of leatherback (*Dermochelys coriacea*) hatchlings were intersexes. Vogt cites this as an example of the danger of eggs incubating near the pivotal temperature. It may instead turn out to be an example of the danger of using a technique that is unreliable for sexing sea turtles. The leatherback gonad, it should be noted, is an especially difficult case because it is less differentiated at hatching than that of other sea turtles studied so far (Rimblot et al., 1985; Dutton et al., 1985).

Benabib's (1984) 14% intersex figure for leatherbacks is far higher than the few percent intersexes found in other studies of sea turtles (Table 1). Moreover, leatherbacks appear to have a remarkably narrow transitional range of temperature (Rimblot-Baly et al., 1987), not much more than 1°C. This means that there is only a range of about 1–2°C within which both sexes can be produced; outside this range either all males or all females are produced (see Mrosovsky and Pieau, 1991, for definitions). If the transitional range is narrow, the chances of producing an intersex will be similarly constrained. Therefore, in variable natural conditions, one would expect *fewer* intersexes from leatherback nests than from clutches of species with wider transitional ranges of temperature (Mrosovsky, 1980). This makes the figure of 14% intersexes given by Benabib (1984) all the more puzzling because it is much higher than those reported for other marine turtles (Table 1).

The 14% intersex figure for leatherbacks is not the only reason given by Vogt for avoiding incubation near the pivotal temperature. Additional points come from considering the sex ratio in natural nests, but here again there is disagreement. Vogt argues that "if the natural condition is to produce one sex or the other in a nest, it may be wise for conservation biologists to do the same." Note the wisdom-of-nature philosophy here. "In fact," Vogt says, "most studies of sea turtles have found that the majority of nests sampled were unisexual." According to our reading of the literature, there are plenty of clutches in natural conditions that produce some of each sex (Table 1; see also Moll, 1994). Intersexes are a rarity in these clutches. To produce some of each sex, the average temperature presumably has to be relatively close to the pivotal temperature.

For these reasons we are less concerned than Vogt about the danger of producing intersexes from incubating close to

Table 1. Occurrence of intersexes and both sexes in sea turtle nests.

Species	Location	Date	Nests Sampled [a]	Clutches with Both Sexes [b]	Intersexes [c]	Reference
Chelonia mydas	Costa Rica	1980	15	66.7%	—— [d]	Spotila et al., 1987
Chelonia mydas	Suriname	1982	82	73.2%	1.1%	Mrosovsky et al., 1984a
Chelonia mydas	Suriname	1993	79	67.1%	0.3%	Godfrey et al., in prep.
Dermochelys coriacea	Suriname	1982	29	31.0%	—— [e]	Mrosovsky et al., 1984a
Dermochelys coriacea	French Guiana	1981-84	34	50.0%	—— [d]	Rimblot-Baly et al., 1987
Dermochelys coriacea	Mexico	1983-84	103	90.3-93.2%	14.0%	Benabib, 1984
Dermochelys coriacea	Suriname	1993	27	37.0%	2.3% [f]	Godfrey et al., in prep.
Caretta caretta	So. Carolina & Georgia, USA	1979-1982	19	57.9%	0.0%	Mrosovsky et al., 1984b
Caretta caretta	Tongaland	198?	17	41.2%	0.0% [g]	Maxwell et al., 1988
Caretta caretta	Florida, USA	1986-88	122	18.9%	0.2%	Mrosovsky & Provancha, 1989, 1992

[a] only natural nests are considered in this survey.
[b] these figures are likely to be underestimates because only subsamples of hatchlings from each clutch were analyzed.
[c] definition of intersex varies according to author.
[d] assumed to be 0% (no intersexes reported).
[e] 7.4% of hatchlings were classified as "indeterminate"; some of these may have been intersexes, but many were probably relatively undifferentiated animals retaining traces of bisexual characteristics from an earlier developmental stage (Dutton et al., 1985).
[f] some of these showed only minor signs of intersexuality and may have become fully sexually differentiated later.
[g] one relocated nest was reported to have intersexes present.

the pivotal temperature. We do agree with Vogt that having male- and female-producing hatcheries may be useful, but not primarily to avoid intersexes. The main advantage of the ladies and gents method (Fig. 1) is that it provides a technologically undemanding way of producing desired numbers of male and female turtles, as previously suggested by Dutton et al. (1985).

This brings us to the most controversial part of Vogt's article, the matter of deliberately producing female-biased sex ratios. Vogt writes that "during the next 50 years we should see populations of many species increase if incubation temperatures are managed to produce a higher percentage of females. Purists will say that this method is unnatural, but the natural approach is to let the populations die off." Note the wisdom-of-nature philosophy has been set aside. Vogt continues: "Take your pick: produce 6 to 20 females

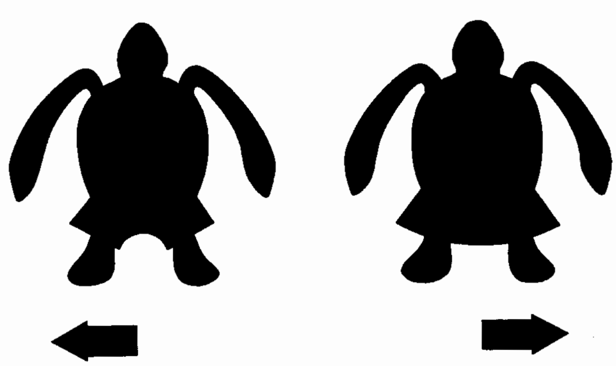

Figure 1. Logo for male and female sea turtle hatcheries, presented at the 5th Annual Workshop on Sea Turtle Biology and Conservation, 1985, Georgia.

per male to ensure the survival of the population, or produce a 1:1 sex ratio because that is what happens in humans...I see no alternative." These recommendations are offered with virtually no qualifications or cautions. No way of knowing whether sex ratio manipulation had been a critical factor in boosting populations, should this happen, is proposed. Launching into some superficially attractive scheme is reminiscent of headstarting (Mrosovsky, 1983; Woody, 1990; Taubes, 1992). Whatever its merits may be, in some cases headstarting has been undertaken without sufficient thought given to exactly how it should be evaluated. In the case of headstarting Kemp's ridleys (*Lepidochelys kempii*), the hypotheses and ways of assessing them seem to have been formulated after the project had been run for a number of years (Eckert et al., 1994).

We are by no means arguing against experimental sex ratio manipulations. We are advocating that evaluation of the methodology be included at the outset. This should include consideration of the following: the suggestion that poor hatch rates of leatherbacks in Malaysia may be attributable to insufficient numbers of males to fertilize clutches (Chan, 1991), the idea that the probability of nesting increases as a function of the duration of mating, up to 5 hours (Wood and Wood, 1980), the potential role of multiple paternity (Harry and Briscoe, 1988) in demographic structure, and much else.

The suggestion that feminizing turtle populations might, and perhaps even should, be tried has been made previously. In the context of the uncertainties that had arisen about headstarting, a plea was made for the risks of feminizing to be considered and for thought to be given to making the experiments as informative as possible (Mrosovsky, 1981). With the probable effect of rapid global warming (greenhouse effect) on reptilian sex ratios (Janzen, 1994; Mrosovsky et al., 1984a), debate on management strategies is needed even more. If Vogt's article stimulates such debate, it will have done a valuable service.

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