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G-Banded Karyotype and Ideogram for the North Atlantic Right Whale (*Eubalaena glacialis*)

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Published cytogenetic data for extant cetacean species remain incomplete. In a review of the literature, we found karyotypic information for 6 of the 13 tentatively recognized species of the suborder Mysticeti (baleen whales). Among those yet to be described is the critically endangered North Atlantic right whale (*Eubalaena glacialis*). Herein, we describe and propose a first-generation G-banded karyotype and ideogram for this species ($2n = 42$), obtained from peripheral blood chromosome preparations from a stranded male calf. This information may prove useful for future genetic mapping projects and for interspecific and intraspecific genomic comparisons by techniques such as zoo-FISH.

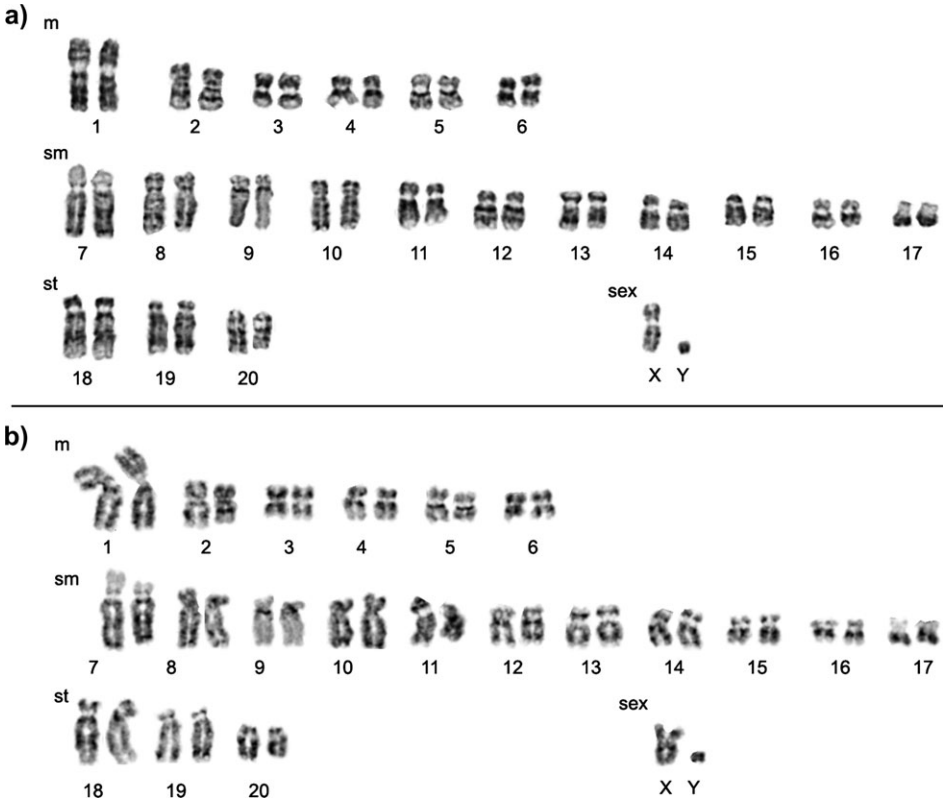

Figure 1. **(a and b)** Representative GTG-banded karyotypes for the North Atlantic right whale (*Eubalaena glacialis*). Metacentric (m), submetacentric (sm), subtelocentric (st), and the sex chromosomes (sex) are depicted in groups as described.

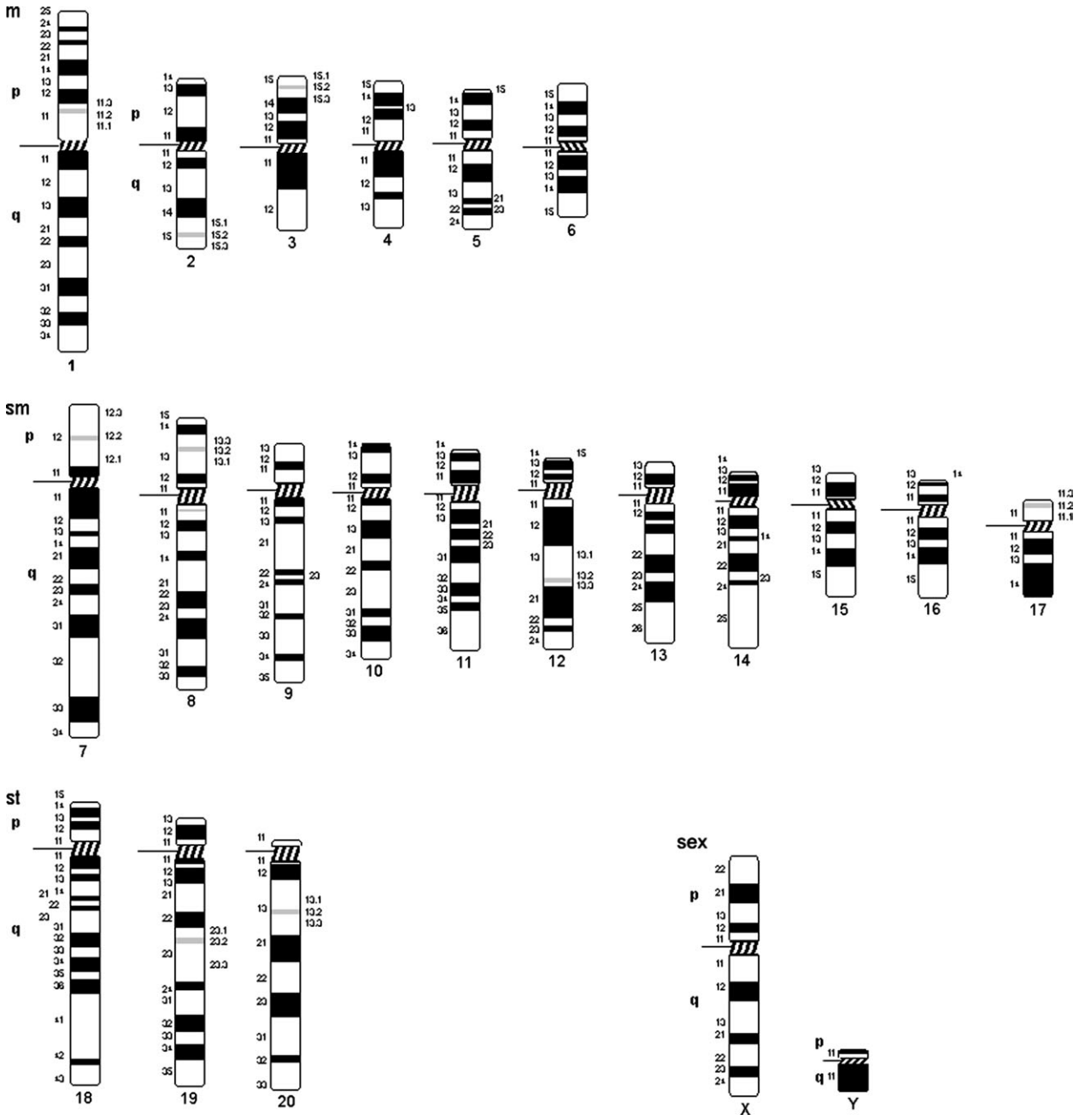

Figure 2. A 300-band G-band ideogram for the North Atlantic right whale (*Eubalaena glacialis*). Relative sizes and *q*/*p* arm ratios are presented in the ideogram as approximations.

The North Atlantic right whale (*Eubalaena glacialis*), one of 13 recognized species of the suborder Mysticeti (baleen whales), is considered one of the most endangered cetaceans, with a population estimate of approximately 300 individuals (Knowlton et al. 1994; Kraus et al. 2001). Although there have been multiple genetic studies for *E. glacialis* assessing the population status and genetic diversity via the use of microsatellites and mitochondrial DNA (Arnason et al. 1993; Malik et al. 2000; Rosenbaum et al. 2000; Waldick et al. 2002), to our knowledge there have been no published reports describing a conventional or banded karyotype for this species.

The winter months of December through March are considered the calving season for *E. glacialis*, correlating with a migration to the calving grounds off the Atlantic coastal areas of the continental United States in the north Florida and south Georgia regions (Knowlton et al. 1994). In February 2004, a live-stranded North Atlantic right whale calf (RKB-1457) was discovered on American Beach, Amelia Island, Florida, United States. (30°35′30″N, 81°26′30″W). Prior to its

Table 1. Relative lengths and arm ratios of North Atlantic right whale (*Eubalaena glacialis*) chromosomes based on measurements from five metaphase cells. Chromosome pairs were assigned to a given morphological group following the method as described by Levan et al. (1964)

Groups	Assigned chromosomes	Relative mean length	Mean *q*/*p* arm ratio
Metacentric	1	4.14	1.26
	2	2.47	1.47
	3	1.96	1.20
	4	1.91	1.45
	5	1.86	1.25
	6	1.65	1.37
Submetacentric	7	3.69	2.30
	8	3.17	1.88
	9	2.90	2.83
	10	2.83	2.13
	11	2.47	1.92
	12	2.23	1.89
	13	2.16	1.79
	14	1.95	1.81
	15	1.82	2.18
	16	1.61	1.72
	17	1.43	2.01
Subtelocentric	18	3.52	3.08
	19	2.83	3.16
	20	2.16	5.95
Sex chromosomes	X	2.55	1.57
	Y	na	na

demise, a blood sample was obtained from the tail fluke, which provided a rare opportunity to generate cytogenetic preparations for this species.

Methods

Blood cultures for cytogenetic preparations were prepared following culturing techniques, as previously described for the Florida manatee (Gray et al. 2002). GTG-banding was performed as a primary chromosome-banding procedure to facilitate specific identification of all homologs (Seabright 1971).

Five complete sets of chromosomes were measured for relative total length, and arm ratios (*q*/*p*) were calculated. Karyotypes were constructed by pairing and grouping chromosomes according to morphologies, relative lengths, and banding patterns. Metaphase imaging and karyotype production were facilitated by computer-assisted methods utilizing CytoVision Genus software (Applied Imaging, Inc., San Jose, CA). To facilitate comparison with other species, the karyotype groups were presented in a fashion similar to the published karyotype for the bowhead whale, *Balaena mysticetus* (Jarrell 1979), as well as for other published cetacean species (Figure 1a,b). A proposed first-generation ideogram for the karyotype of this species was constructed based on the G-banded metaphase images using conventional computer graphics software (Figure 2).

Results

Nineteen metaphase cells of suitable quality for karyotyping and/or counting were obtained from the cell culture established, and the modal chromosome number was determined to be 42. The karyotype was divided into three distinctive autosomal groups (Table 1), with the sex chromosomes depicted separately. Six pairs were assigned to the metacentric group, 11 pairs were assigned to the submetacentric group, and 3 pairs were assigned to the subtelocentric group.

Discussion

In a review of the literature, we found karyotypic data for 6 of the 13 species of the suborder Mysticeti (Table 2). Among the four tentatively recognized members of the family Balaenidae [*Balaena mysticetus* (bowhead whale), *E. glacialis* (North Atlantic right whale), *Eubalaena japonica* (North Pacific right whale), and *Eubalaena australis* (Southern right whale)], we found karyotype data for only *B. mysticetus* (Jarrell 1979), which also contained a chromosome count of 42. Further comparison with that of the published karyotype of *B. mysticetus* revealed multiple pairs of chromosomes with analogous morphologies

Table 2. Published karyotypic data for the suborder Mysticeti (baleen) whales

Family	Species	2*n*	Banding methods	Reference
Eschrichtiidae	*Eschrichtius robustus*[a] (gray whale)	44	G, C, NOR	Arnason (1974, 1981)
Balaenopteridae	*Balaenoptera acutorostrata* (minke whale)	44	G, C	Arnason (1974), Arnason et al. (1977)
	Balaenoptera bonaerensis (Antarctic minke whale)	—		—
	Balaenoptera borealis (sei whale)	44	G, Q, C	Arnason (1974)
	Balaenoptera edeni (Bryde's whale)	—		—
	Balaenoptera musculus (blue whale)	44	Solid, C	Arnason et al. (1985)
	Balaenoptera physalus (fin whale)	44	G, Q, C	Arnason (1969)
	Megaptera novaeangliae (humpback whale)	—		—
Balaenidae	*Balaena mysticetus* (bowhead whale)	42	Solid, G	Jarrell (1979)
	Eubalaena australis (Southern right whale)	—		—
	Eubalaena glacialis (North Atlantic right whale)	42	G	Present study
	Eubalaena japonica (North Pacific right whale)	—		—
Neobalaenidae	*Caperea marginata* (pygmy right whale)	—		—

[a] Formerly *Eschrichtius gibbosus*.

and banding patterns, including several with different morphological group assignments. For example, the chromosome pair 17 reported here as submetacentric appears very similar in both relative size and banding pattern to the chromosome pair 7 reported as metacentric for *B. mysticetus*. We believe that some of the morphological differences reported between these two species may simply reflect differences in the measurement techniques employed by the investigators, especially in the metacentric and submetacentric groups. However, clear structural differences between these two species also appear evident by comparison. Although, we choose not to assign any of *E. glacialis* chromosomes to a telocentric group, as all chromosomes included a measurable short arm, the chromosome 20 pair was the only pair whose morphology approached a telocentric appearance in this study, whereas, three such pairs are described in *B. mysticetus*.

Although the cytogenetic data presented here are limited in quantity and quality, representing only a single animal, we believe that, in light of the rarity of opportunities to study the North Atlantic right whale, the karyotypic data obtained warrant presentation. The karyotype data and technical parameters for this single individual could provide a foundation for future studies, including the refinement of the karyotype of this species, as well as detailed interspecific and intraspecific karyotypic comparisons currently not possible.

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