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Etologia. — *Satellite tracking data on Malaysian Green Turtle migration.* Nota di HOCK-CHARK LIEW, ENG-HENG CHAN, PAOLO LUSCHI e FLORIANO PAPI, presentata (*) dal Corrisp. F. Papi.

ABSTRACT. — Satellite telemetry has been used on green turtle (*Chelonia mydas*) females nesting in West Malaysia to study their migratory routes, behaviour during migration and homing after displacement. For three turtles the complete migratory journey was tracked, while another one was followed for part of the trip. The return path to the nesting beach following displacement of one of the turtles from 284 km was also tracked. All the useful localizations are reported, thus providing the basic information for further analysis.

KEY WORDS: Satellite tracking; Migration; Homing; Green Turtle.

RIASSUNTO. — *Rilevamenti via satellite delle rotte migratorie di tartarughe verdi della Malesia.* La telemetria via satellite è stata impiegata su femmine di tartaruga verde (*Chelonia mydas*) nidificanti nella Malesia occidentale al fine di studiarne le vie di migrazione, il comportamento durante la migrazione e l'homing dopo dislocamento. Tre femmine sono state seguite per tutta la migrazione, una quarta per solo parte di essa. Di una delle tartarughe è stato ricostruito anche il percorso di ritorno al luogo di nidificazione dopo dislocamento a 284 km di distanza. Tutti i punti rilevati dagli animali sono riportati per fornire i dati essenziali per ulteriori analisi.

INTRODUCTION

Through tagging programs, mounting evidence has shown that sea turtles migrate long distances between their foraging and nesting grounds (Balazs, 1976; Carr *et al.*, 1978; Green, 1984; Meylan, 1982; Mortimer and Carr, 1987; Limpus *et al.*, 1992). However, tag recovery data are often scarce and are unable to provide information on routes taken, speed of travel and what the turtles do during the migration. The recent advent of satellite tracking technology has made it possible to provide fairly accurate accounts of the migration patterns of numerous animals (Taillade, 1993) including sea turtles (*e.g.* Stoneburner, 1982; Byles and Keinath, 1990; Balazs, 1994; Balazs *et al.*, 1994). As the use of satellite technology in sea turtle tracking is still being perfected, there is a lack of good tracking data for many of the turtle species.

In 1993, we successfully tracked by satellite a green turtle from her nesting beach on Redang Island in Peninsular Malaysia to her foraging grounds in the Natuna Islands in Indonesia (Papi *et al.*, 1995). The present paper presents satellite tracking data obtained in 1994 from another four green turtles as they migrate from their nesting beach at Redang Island in Peninsular Malaysia to their foraging grounds. It represents part of the research work on the long distance migration of sea turtles in the Southeast Asian Region we have initiated using satellite telemetry.

MATERIALS AND METHODS

The satellite tracking study was carried out on female green turtles nesting on the Chagar Hutang beach (5.816° N, 103.008° E) of Redang Island, which is located 45 km

(*) Nella seduta del 22 aprile 1995.

off the eastern coast of Terengganu, Peninsular Malaysia. Redang Island is the largest of a group of nine coral-fringed islands that have been gazetted as a Marine Park.

We used four Telonics ST-3 Platform Transmitter Terminals (PTTs), linked to the Argos System (see Taillade, 1992 for further information). These were fitted with a salt-water switch and had a repetition rate of between 49 and 51 sec. The duty cycle was set continuously to «on» due to poor satellite passes near the equator and to track the migration route as closely as possible. Each PTT weighed about 750 g and measured 16.5 × 9.8 × 3.0 cm.

The satellite transmitters were glued on top of the carapace (on the second dorsal central scute) with some modifications to the techniques described in Balazs (1994) and in Balazs *et al.* (1994). The deployment was performed as soon as the turtle has completed camouflaging her nest. This reduced the chance of the turtle throwing sand during the attachment process. Wooden poles were pushed into the sand near the shoulders to restrain the turtle while a dark cloth placed over its head helped calm the turtle.

The carapace area for attachment was first cleaned by sanding with fine-grained sandpaper. A thin layer of polyether adhesive was then applied on the attachment area. As the adhesive was being applied, a 500 g mixture of Vinyl Polysiloxane dental impression material (putty type) was prepared by mixing equal parts of the base and catalyst. The putty mixture was then pressed onto the adhesive on the carapace and shaped to present a flat surface for the PTT. The PTT was then pressed onto the dental putty and the putty rapidly moulded before it cured so that the PTT base plate was held and sat well against the contour of the carapace. Two to three layers of fiberglass cloth and resin were then applied over the PTT as described by Beavers *et al.* (1992) and Renaud *et al.* (1993). The fiberglass coating dried in 1.5 to 2 hrs after which the turtle was allowed to crawl back into the sea carrying the satellite transmitter.

The turtles chosen for deployment were identified as those expected to leave for their foraging grounds based on their nesting records for the season. A long-term tagging and nesting research program conducted by the Malaysian authors provided detailed information on the nesting chronology of each individual turtle. The four turtles studied were designated as turtles A-D according to the order in which the PTT was deployed.

Turtle A, after her 7th nesting on 26th Aug. 1994, was transported to a beach near Nenasi, Pahang (3.283° N; 103.433° E), 284 km south of Redang Island along the mainland coast in a displacement experiment. Equipped with PTT #22606, she was released and allowed to crawl into the sea at 15:08 hrs Malaysian time on 27th Aug. 1994. Turtle B was fitted with PTT #22819 after her 9th nesting and released on 6th Sept. 1994. However, she nested for the 10th time on 20th Sept. 1994 before making her long distance migration. Turtle C was fitted with PTT #22818 on 9th Sept. 1994 after her 8th nesting. Turtle D was deployed with PTT #22817 on 16th Sept. 1994 after her 7th nesting. She made one more nesting on 27th Sept. 1994 before her long distance migration.

The locations (or fixes) were calculated by Argos on the basis of the quality of trans-

missions received through their satellites from each of the coded PTTs when the turtles surfaced for air. The longer the turtle remains on the surface while the receiving satellites were overhead, the better the accuracy of the fixes obtained. As told by the Argos to the users, from June 1994 the fixes are assigned to six location classes (*i.e.* 3, 2, 1, 0, A and B), according to the estimated accuracy of the locations obtained. For classes 3, 2 and 1, Argos gives the degree of accuracy (for one standard deviation) as 150 m, 350 m and 1 km respectively.

Results

Of the four turtles fitted with PTTs, three were successfully tracked until they reached their destination foraging grounds. No transmissions were received from the fourth PTT (Turtle D with PTT #22817) after 17 days. Results on the fixes obtained for Turtles A, B, C and D are reported in tables I, II and III. A reconstruction of the tracks is given in fig. 1.

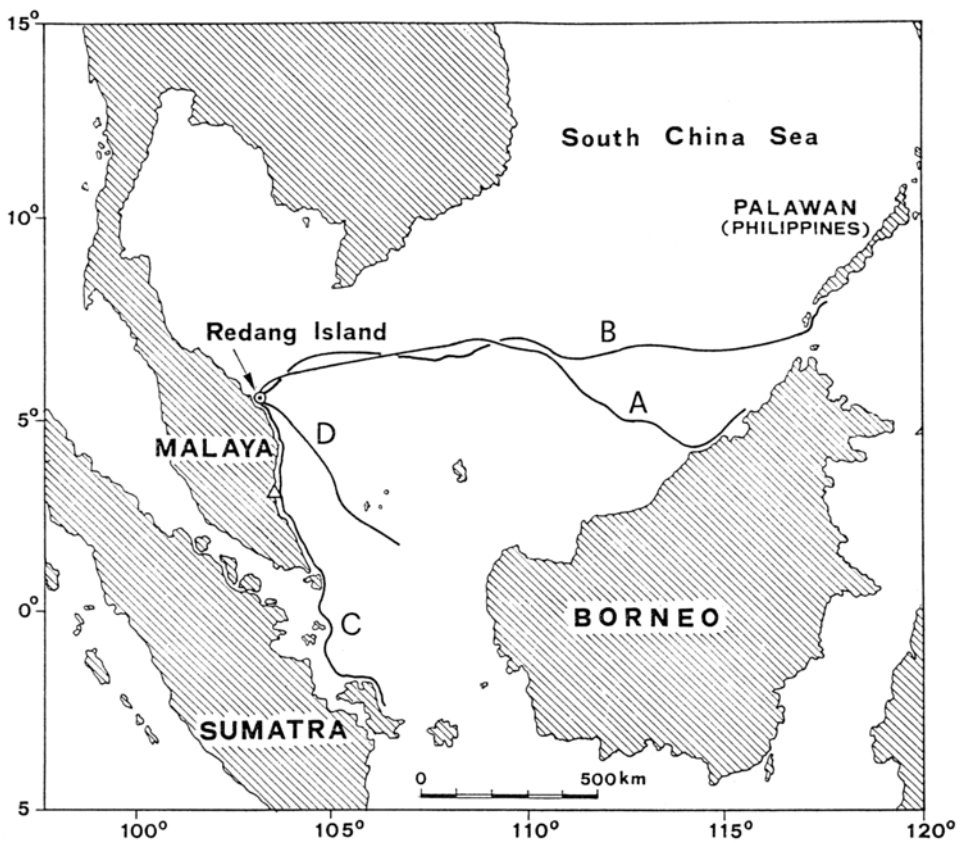

Fig. 1. – Reconstruction of the migratory routes of the four tracked turtles. The homing route after displacement of turtle A is not given: the turtle swan coastwise from the release site (indicated by a triangle) to Redang Island.

TABLE I. – *Locations of turtle A. Time is expressed as Malaysian standard time* (GMT + 8 hrs). *C. refers to location classes (see text). Direction and distances are calculated with respect to the preceding location.*

N.	Date	Time	Lat. (deg.)	Long. (deg.)	C.	Dir. (deg.)	Dist. (km)
Homing trip							
1	31/08	05:09	004.217	103.500	1		
2	31/08	08:05	004.219	103.622	B	089	13.55
3	01/09	04:56	004.777	103.483	1	346	63.60
4	02/09	17:31	005.489	103.118	0	333	88.53
5	02/09	19:12	005.550	103.112	1	354	6.78
6	03/09	17:19	005.795	103.045	0	345	28.09
Migration							
1	09/09	20:47	005.887	103.057	0		
2	10/09	07:47	006.025	103.099	A	017	15.95
3	10/09	17:35	006.223	103.241	A	036	26.95
4	10/09	18:49	006.244	103.268	B	052	3.78
5	11/09	09:01	006.303	103.496	A	075	26.06
6	11/09	17:20	006.394	103.640	1	058	18.84
7	12/09	07:01	006.493	103.933	B	071	34.21
8	12/09	08:42	006.512	103.955	0	049	3.22
9	12/09	21:28	006.624	104.281	B	071	38.12
10	13/09	07:28	006.658	104.504	B	081	24.94
11	13/09	16:56	006.737	104.760	A	073	29.62
12	13/09	18:39	006.751	104.823	2	077	7.13
13	14/09	07:59	006.851	105.178	A	074	40.77
14	14/09	09:41	006.840	105.214	A	107	4.16
15	14/09	16:46	006.868	105.324	B	076	12.55
16	14/09	20:43	006.882	105.509	1	086	20.51
17	15/09	05:20	006.912	105.785	0	084	30.68
18	15/09	07:05	006.923	105.775	2	318	1.64
19	15/09	18:12	006.953	106.080	A	084	33.87
20	15/09	18:40	006.960	106.078	B	344	0.81
21	16/09	07:17	007.035	106.383	B	076	34.71
22	16/09	08:56	007.037	106.407	1	085	2.66
23	16/09	18:00	007.067	106.682	A	084	30.56
24	17/09	05:04	007.073	106.917	B	089	25.97
25	17/09	06:04	007.097	106.944	1	048	3.99
26	17/09	08:35	007.098	106.972	1	088	3.10
27	17/09	21:16	007.138	107.320	1	083	38.70
28	18/09	06:29	007.141	107.442	A	089	13.48
29	18/09	08:10	007.150	107.519	B	083	8.56
30	18/09	17:35	007.186	107.777	3	082	28.78
31	19/09	06:13	007.289	108.072	B	071	34.51
32	19/09	20:30	007.424	108.534	B	074	53.15
33	20/09	07:29	007.366	108.710	B	108	20.46
34	20/09	09:07	007.385	108.767	B	072	6.63
35	20/09	17:13	007.346	108.910	A	105	16.37
36	20/09	18:33	007.355	108.947	B	076	4.20
37	21/09	05:51	007.290	109.105	A	112	18.87
38	21/09	07:07	007.271	109.137	B	121	4.11
39	21/09	16:57	007.235	109.328	B	101	21.47
40	21/09	18:40	007.248	109.373	B	074	5.17
41	21/09	19:53	007.233	109.386	A	139	2.19
42	22/09	08:27	007.188	109.625	1	101	26.86
43	22/09	16:49	007.157	109.828	B	099	22.68
44	22/09	18:27	007.141	109.865	A	113	4.45
45	23/09	16:36	007.076	110.223	B	100	40.20
46	23/09	20:45	007.080	110.261	A	084	4.22
47	24/09	05:13	007.067	110.348	B	098	9.72
48	24/09	07:40	007.057	110.360	B	130	1.73
49	24/09	09:22	007.111	110.410	B	043	8.14
50	24/09	18:03	007.001	110.504	B	139	16.00
51	25/09	07:21	006.923	110.551	A	149	10.07
52	26/09	04:47	006.751	110.701	B	139	25.23
53	26/09	06:29	006.740	110.697	B	200	1.29
54	26/09	06:59	006.740	110.694	A	270	0.33
55	26/09	08:36	006.726	110.751	B	104	6.49
56	26/09	17:38	006.578	110.841	A	149	19.16
57	27/09	08:17	006.329	110.950	B	156	30.06
58	27/09	17:30	006.244	111.216	B	108	30.90
59	28/09	17:12	005.852	111.549	A	140	56.91
60	28/09	20:40	005.821	111.686	B	103	15.55
61	29/09	05:54	005.703	111.826	B	130	20.27
62	29/09	09:12	005.692	111.913	B	097	9.71
63	29/09	17:03	005.618	112.067	A	116	18.92
64	29/09	18:37	005.592	112.105	0	124	5.10
65	29/09	20:18	005.576	112.143	A	113	4.57
66	30/09	07:13	005.396	112.299	A	139	26.36
67	30/09	08:54	005.379	112.339	A	113	4.81
68	30/09	16:48	005.369	112.547	A	093	23.08
69	01/10	05:29	005.357	112.755	A	093	23.09
70	01/10	06:53	005.349	112.818	B	097	7.04
71	01/10	08:30	005.364	112.865	B	072	5.47
72	01/10	16:36	005.310	113.052	B	106	21.57
73	01/10	18:18	005.347	113.075	1	032	4.82
74	01/10	19:32	005.334	113.111	B	110	4.24
75	02/10	06:31	005.146	113.253	B	143	26.08
76	02/10	08:11	005.136	113.291	B	105	4.36
77	02/10	18:06	005.049	113.478	A	115	22.86
78	03/10	06:44	004.857	113.648	B	138	28.40
79	03/10	16:11	004.785	113.855	A	109	24.30
80	03/10	17:52	004.769	113.901	3	109	5.40
81	04/10	04:54	004.725	113.971	B	122	9.16
82	04/10	07:25	004.688	114.044	B	117	9.07
83	04/10	17:41	004.690	114.238	A	089	21.53
84	05/10	06:20	004.677	114.439	B	094	22.35
85	05/10	19:47	004.738	114.635	A	073	22.77
86	06/10	04:30	004.845	114.672	B	019	12.52
87	06/10	06:07	004.865	114.687	B	037	2.77
88	06/10	17:15	004.933	114.810	B	061	15.58
89	07/10	05:51	004.892	114.956	B	106	16.82
90	07/10	17:06	005.155	115.055	0	021	31.09
91	08/10	05:43	005.129	115.070	B	150	3.32
92	08/10	18:45	005.362	115.194	B	028	29.20
93	09/10	16:38	005.567	115.471	2	053	38.16

The first migratory fix for Turtle A was obtained 3 days 13 hrs after deployment at a location 104 km north of the release site at 4.217° N, 103.500° E. She then continued her journey northwards, following the coast, and reached the waters near Redang Island on 3rd Sept. 1994. She made her 8th and final nesting on 8th Sept. 1994 and sub-

TABLE II. – *Locations of turtles B and C. For explanations see table I.*

N.	Date	Time	Lat. (deg.)	Long. (deg.)	C.	Dir. (deg.)	Dist. (km)
Turtle B							
1	21/09	08:49	005.931	102.928	B		
2	21/09	19:49	006.023	103.215	1	072	33.37
3	21/09	21:27	006.096	103.325	A	056	14.61
4	22/09	10:07	006.258	103.390	B	022	19.31
5	22/09	18:27	006.337	103.586	1	068	23.38
6	23/09	05:28	006.505	103.742	1	043	25.36
7	23/09	09:44	006.570	103.814	A	048	10.73
8	23/09	18:16	006.688	104.030	2	061	27.22
9	23/09	20:49	006.696	104.063	0	076	3.76
10	24/09	07:42	006.868	104.320	A	056	34.19
11	24/09	09:23	006.884	104.346	0	058	3.37
12	24/09	20:26	006.943	104.720	A	081	41.85
13	25/09	05:06	006.982	104.972	B	081	28.18
14	25/09	07:22	007.019	105.051	B	065	9.64
15	25/09	19:32	006.803	105.415	A	121	46.79
16	25/09	21:45	007.006	105.476	A	017	23.44
17	26/09	06:59	007.044	105.667	A	079	21.52
18	26/09	08:39	007.040	105.701	3	097	3.78
19	28/09	17:14	006.891	107.238	1	096	170.65
20	28/09	18:52	006.908	107.290	A	072	6.05
21	29/09	07:34	006.860	107.559	2	100	30.20
22	29/09	09:17	006.846	107.644	A	099	9.52
23	29/09	17:01	006.955	107.848	1	062	25.57
24	29/09	18:37	006.985	107.892	A	056	5.89
25	30/09	05:40	006.957	108.101	0	098	23.30
26	30/09	07:23	006.965	108.141	B	079	4.51
27	30/09	16:49	007.023	108.416	2	078	31.06
28	01/10	05:29	007.093	108.663	3	074	28.37
29	01/10	08:30	007.129	108.703	1	048	5.95
30	01/10	16:35	007.216	108.894	B	066	23.19
31	01/10	18:16	007.250	108.941	2	054	6.41
32	02/10	06:30	007.402	109.135	0	052	27.23
33	02/10	20:50	007.375	109.523	0	094	42.94
34	03/10	06:45	007.352	109.758	2	096	26.07
35	03/10	07:46	007.353	109.773	1	086	1.66
36	03/10	09:27	007.353	109.825	A	090	5.74
37	04/10	06:31	007.213	110.274	2	107	51.95
38	04/10	07:23	007.209	110.278	B	135	0.63
39	04/10	09:05	007.185	110.342	1	111	7.55
40	05/10	04:41	006.904	110.808	A	121	60.14
41	05/10	06:18	006.902	110.863	A	092	6.08
42	07/10	19:03	007.086	112.212	B	082	150.45
43	08/10	20:19	007.258	112.904	B	076	78.77
44	13/10	04:43	007.133	114.933	B	094	224.53
45	16/10	20:46	007.544	116.889	B	078	220.71
46	18/10	07:00	008.069	117.091	0	021	62.19
47	19/10	16:16	008.241	117.370	A	058	36.16
Turtle C							
1	11/09	20:07	005.558	103.064	1		
2	12/09	18:48	005.446	103.128	B	150	14.27
3	12/09	21:25	005.321	103.196	A	151	15.74
4	13/09	10:00	005.263	103.294	B	121	12.62
5	13/09	21:07	005.121	103.255	B	195	16.29
6	14/09	05:37	005.124	103.323	B	087	7.55
7	14/09	07:20	005.026	103.333	B	174	10.89
8	14/09	09:38	004.982	103.400	B	123	8.88
9	14/09	18:25	004.853	103.398	B	181	14.27
10	14/09	20:41	004.839	103.427	A	116	3.57
11	15/09	07:06	004.699	103.460	B	167	15.91
12	15/09	09:16	004.664	103.477	0	154	4.31
13	16/09	06:55	004.393	103.468	B	182	29.98
14	16/09	07:15	004.388	103.469	B	169	0.56
15	16/09	08:53	004.347	103.490	A	153	5.10
16	17/09	05:04	004.186	103.399	B	209	20.47
17	17/09	06:44	004.114	103.453	A	143	9.97
18	17/09	08:33	004.080	103.468	0	156	4.11
19	17/09	17:51	003.976	103.504	B	161	12.18
20	18/09	09:50	003.771	103.473	B	189	22.93
21	18/09	20:53	003.679	103.481	B	175	10.21
22	19/09	06:15	003.599	103.524	A	152	10.05
23	19/09	07:50	003.602	103.506	B	279	2.03
24	19/09	17:22	003.492	103.586	0	144	15.07
25	20/09	18:52	003.202	103.623	B	173	32.33
26	21/09	08:47	003.032	103.516	A	212	22.25
27	22/09	16:45	002.651	103.833	B	140	54.93
28	22/09	18:23	002.632	103.816	B	222	2.83
29	23/09	05:32	002.569	103.820	B	176	6.98
30	23/09	08:06	002.452	103.896	B	147	15.45
31	23/09	09:46	002.430	103.915	B	139	3.22
32	23/09	20:40	002.357	103.996	B	132	12.10
33	24/09	06:58	002.142	104.046	B	167	24.42
34	25/09	07:23	001.750	104.225	A	155	47.70
35	25/09	09:00	001.711	104.206	B	206	4.80
36	26/09	04:50	001.416	104.269	B	168	33.36
37	26/09	08:41	001.374	104.362	B	114	11.34
38	26/09	19:40	001.182	104.406	B	167	21.79
39	27/09	08:19	001.218	104.638	0	081	26.13
40	27/09	17:24	001.135	104.649	B	172	9.26
41	28/09	04:27	001.063	104.667	B	166	8.21
42	28/09	17:14	000.734	104.691	B	176	36.48
43	28/09	19:00	000.727	104.699	B	131	1.18
44	29/09	07:36	000.671	104.691	B	188	6.26
45	29/09	09:19	000.665	104.717	B	103	2.97
46	29/09	16:56	000.497	104.475	B	235	32.72
47	30/09	07:14	000.386	104.578	B	137	16.80
48	30/09	08:58	000.408	104.639	B	070	7.21
49	30/09	16:45	000.226	104.573	B	200	21.42
50	30/09	19:50	000.178	104.521	B	227	7.85
51	01/10	05:34	000.103	104.755	B	108	27.34
52	01/10	16:34	-000.084	104.725	B	189	20.95
53	01/10	18:14	-000.099	104.782	A	105	6.56
54	02/10	06:57	-000.211	104.920	B	129	19.73
55	02/10	18:03	-000.448	104.945	B	174	26.35
56	03/10	05:03	-000.598	104.903	B	196	17.23
57	03/10	17:50	-000.992	104.985	A	168	44.51
58	04/10	04:51	-000.982	104.887	B	276	10.96
59	04/10	17:37	-001.193	105.032	A	146	28.37
60	05/10	17:25	-001.463	105.250	A	141	38.47
61	06/10	17:12	-001.500	105.548	B	097	33.41
62	07/10	08:04	-001.372	105.873	B	069	38.84
63	08/10	07:28	-001.646	106.165	B	133	44.43
64	08/10	09:18	-001.683	106.131	B	223	5.57
65	09/10	05:39	-001.771	106.130	B	181	9.73
66	09/10	18:18	-002.137	106.279	B	158	43.73

TABLE III. – *Locations of turtle D. For explanations see table I.*

N.	Date	Time	Lat. (deg.)	Long. (deg.)	C.	Dir. (deg.)	Dist. (km)	N.	Date	Time	Lat. (deg.)	Long. (deg.)	C.	Dir. (deg.)	Dist. (km)
1	28/09	09:37	005.841	103.004	B			23	06/10	17:16	004.387	104.409	B	135	18.72
2	29/09	07:35	005.702	103.191	0	127	25.79	24	06/10	19:27	004.324	104.326	0	233	11.55
3	29/09	18:36	005.757	103.385	0	074	22.33	25	06/10	21:02	004.305	104.304	0	230	3.31
4	30/09	07:13	005.556	103.317	A	199	23.47	26	07/10	09:40	004.173	104.569	B	116	32.84
5	30/09	08:56	005.492	103.353	A	151	8.12	27	07/10	18:41	004.049	104.670	0	141	17.71
6	30/09	16:51	005.449	103.445	B	115	11.25	28	07/10	20:45	004.021	104.701	A	132	4.63
7	30/09	19:54	005.483	103.445	A	360	3.76	29	08/10	07:36	003.842	104.743	B	167	20.34
8	01/10	07:09	005.330	103.478	2	168	17.31	30	08/10	09:20	003.838	104.789	2	095	5.13
9	01/10	16:37	005.315	103.524	0	108	5.36	31	08/10	18:29	003.751	104.898	2	129	15.46
10	01/10	18:14	005.317	103.544	B	084	2.23	32	08/10	20:21	003.724	104.929	B	131	4.56
11	02/10	06:57	005.197	103.607	1	152	15.00	33	09/10	07:08	003.491	105.015	B	160	27.48
12	02/10	09:49	005.197	103.650	A	090	4.77	34	09/10	09:00	003.495	105.047	B	083	3.58
13	02/10	20:47	005.145	103.686	B	145	7.00	35	09/10	18:15	003.399	105.128	0	140	13.92
14	03/10	06:44	005.125	103.708	1	132	3.29	36	10/10	07:02	003.108	105.176	2	171	32.62
15	03/10	07:52	005.121	103.694	A	254	1.61	37	10/10	18:00	002.838	105.271	B	161	31.67
16	03/10	09:26	005.090	103.731	1	130	5.35	38	10/10	19:39	002.841	105.312	1	086	4.57
17	04/10	07:27	005.077	103.769	0	109	4.45	39	11/10	05:06	002.640	105.459	0	144	27.59
18	04/10	17:44	005.010	103.875	0	122	13.90	40	11/10	17:53	002.485	105.756	0	118	37.21
19	05/10	07:04	004.903	103.957	A	143	14.92	41	11/10	19:35	002.489	105.830	B	087	8.24
20	05/10	08:47	004.864	103.988	A	142	5.52	42	12/10	04:56	002.401	105.824	B	184	9.75
21	05/10	21:30	004.590	104.248	B	137	41.84	43	14/10	18:57	001.735	106.847	0	123	135.56
22	06/10	10:04	004.506	104.289	B	154	10.34								

sequently started her migration on 10th Sept. 1994 eastwards to her foraging grounds in the north-western coast of Sabah, East Malaysia.

During the migration phase, the first fix for Turtle B was obtained on 21st Sept. 1994, the day following her final nesting. She headed east crossing the South China Sea and entered the Balabac Straits between Sabah, East Malaysia, and Palawan Island, the Philippines. Her journey ended in the vicinity of Bugsuk Island, south of Palawan Island of the Philippines.

For Turtle C, the first migratory fix was obtained on 11th Sept. 1994 two days after her final nesting. She was tracked heading southwards following the coastline of Peninsular Malaysia, Indonesian Bintang Island and the Lingga Archipelago before ending up on the central eastern coast of Bangka Island, Indonesia.

The first migratory fix for Turtle D was obtained on 28th Sept. 1994. She headed south-east past the Anambas Islands, Indonesia, before transmission stopped after 17 days. It is unlikely that the turtle had reached her foraging grounds.

DISCUSSION

Results obtained in this study conformed with current data which indicate that the green turtle is a migrant travelling long distances between foraging and nesting grounds. All the four turtles tracked in this study, and one the previous year (Papi *et al.*, 1995), were found to take different routes ending at different destinations. None of the turtles migrated north of Redang Island. However, there are no grounds to exclude that this is due to chance.

During the long distance migration, the turtles appeared to spend a fair amount of time on the surface, sufficiently long enough to obtain good fixes on a number of occa-

sions. This was especially so considering the Argos satellite coverage near the equator is only 6-8 passes per day, each with an average duration of 10 minutes.

The method of attachment worked well in all the deployments, enabling us to reconstruct the exact routes taken by the turtles in their long distance migration from their nesting grounds to their foraging grounds. Only Turtle D with PTT #22817 stopped transmission before reaching her foraging grounds. We could not ascertain whether the cause of this interruption in the emissions was the detachment of the PTT or a failure in the transmission of the data. Nevertheless, the use of Vinyl Polysiloxane dental impression material worked just as successfully as the Rolyan Silicone Elastomer prescribed by Balazs (1994) and Balazs *et al.* (1994) as a custom-mounting base for the PTTs.

The results achieved and the experience acquired by the authors of the present study have certainly paved the way for further collaborative work between the Malaysian and Italian teams on Malaysian sea turtles. Migration patterns, navigational abilities and management implications will be discussed in detail in subsequent publications.

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