DETERMINATION OF THE FACTORS THAT MIGHT HAVE INFLUENCED THE REHABILITATION OF *CARETTA CARETTA* IN THE LAMPEDUSA SEA TURTLE RESCUE CENTER BETWEEN 2001-2016

Camilla Roldi & Daniela Freggi

Lampedusa Sea Turtle Rescue Center, Punta Sottile Presso, 92031, Lampedusa e Linosa AG, Italy

Roldi, C. & Freggi, D.: Determination of the factors that might have influenced the rehabilitation of *Caretta caretta* in the Lampedusa Sea Turtle Rescue Center between 2001-2016. Nat. Croat., Vol. 29, Suppl. 1., 59-66, 2020, Zagreb.

The Lampedusa Sea Turtle Rescue Center started its activity in 1990, and in this paper we analyze data from 2812 loggerhead turtlesrescued by 2016. Here we analyse which factors might have affected the rehabilitation success of the injured sea turtles hosted in our Center. We underline the following factors: type of clinical case, animal's health condition and the presence of a qualified surgeon.

For the first factor we estimated the percentage of survival animals with the various clinical cases (n=928) and for the second factor we estimated the outcome of therapies (recovery achieved/death) and health condition (good health condition/depressed/comatose) using the Fisher exact test which confirmed how health condition can significantly affect sea turtle rehabilitation success. For the last factor, we divided the study period into five subperiods (2001-2003, 2004-2006, 2007-2009, 2010-2012, 2013-2016) based on the evolution of surgical techniques and the presence of an expert surgeon with direct experience of sea turtle surgery; with post hoc test of univariate ANOVA investigation, we confirm significantly the value of the experience of professionals involved.Bycatch and health condition appear to significantly influence rehab success and the presence of a competent surgeon is radically responsible for an increase in the survival of loggerhead turtles, as expected.

Key words: marine turtles, rehabilitation success, clinical cases, survival, Lampedusa

Roldi, C. & Freggi, D.: Određivanje čimbenika koji su mogli utjecati na rehabilitaciju glavatih želvi *Caretta caretta* u Centru za spašavanje morskih kornjača Lampedusa između 2001-2016. Nat. Croat., Vol. 29, Suppl. 1., 59-66, 2020, Zagreb.

Centar za spašavanje morskih kornjača Lampedusa počeo je s aktivnostima 1990., a u ovom radu analiziramo podatke 2812 glavatih želvi spašenih do 2016. godine. Analiziramo čimbenike koji su mogli imati utjecaja na uspjeh oporavka ozlijeđenih morskih kornjača smještenih u našem Centru. Naglašavamo sljedeće čimbenike: tip kliničkog slučaja, zdravstveno stanje životinje i prisutnost kvalificiranog kirurga.

Za prvi čimbenik procijenili smo postotak preživljavanja životinja u odnosu na razne kliničke slučajeve (n=928), a za drugi čimbenik procijenili smo ishode liječenja (postignuti oporavak/smrt) i zdravstveno stanje (dobro zdravstveno stanje/depresivna/komatozna) koristeći Fisherov egzaktni test koji je potvrdio da zdravstveno stanje može značajno utjecati na oporavak morske kornjače. Za posljednji čimbenik podijelili smo vrijeme istraživanja u 5 potperioda (2001-2003, 2004-2006, 2007-2009, 2010-2012, 2013-2016), na temelju razvoja kirurških tehnika i prisutnosti kirurga s direktnim iskustvom na operiranju morskih kornjača; koristeći post hoc test univarijatne ANOVA analize, potvrdili smo značajnu vrijednost iskustva prisutnih stručnjaka. Slučajni ulov i zdravstveno stanje značajno utječu na uspjeh oporavka, a kao što je i očekivano, prisutnost kompetentnog kirurga radikalno povećava preživljavanje glavatih želvi.

Ključne riječi: morske kornjače, uspjeh oporavka, klinički slučajevi, preživljavanje, Lampedusa

INTRODUCTION

Over recent decades, the status of sea turtles and the need for their protection have increasingly become topics of public interest (Casale *et al.*, 2008; Casale, 2011), accompanied by a global rise in the number of sea turtle rescue centers. This is particularly true in Italy, where more than 25 of these rehabilitation centers operate. Rehabilitation based on sound conservation and biological principles (Tribe & Brown, 2000; Ferraro & Pattanayak, 2006) ensures that available resources can be allocated to the most effective conservation measures (Tribe & Brown 2000, Ferraro & Pattanayak, 2006; Wimberger *et al.*, 2010; Feck & Hamann, 2013). In some cases, however, the high costs of rehabilitation or low success rates may prohibit widespread implementation (Baker *et al.*, 2010).Thus, understanding the success rates of rehabilitation and how they vary with species biology (e.g. body size, sex) will enhance our ability to gauge how these activities can contribute to conservation (Lazar *et al.*, 2004; Beker *et al.*, 2015; Casale *et al.*, 2016).

Sea turtle rehabilitation is usually achieved through medical management of sick or injured animals by veterinary surgeons in wildlife hospitals (Casal & Orós, 2009; Feck & Hamann, 2013). The majority of animals in rehabilitation are taken there because of some previous negative interaction with humans, including entanglement in fishing gear (Bentivegna, 1993; Allen, 2000; RAC/SPA, 2004; Bagarinao, 2011), being hit by a boat or propeller and a wide range of other causes (Bagarino, 2011). Wide spread rehabilitation of sick or injured turtles currently supplements other conservation efforts (Casal & Orós, 2009; Mestre *et al.*, 2014), but we still have a poor understanding of the conservation potential of rehabilitation in terms of numbers of healthy animals released (even without any knowledge of their longer-term individual survival (Mestre *et al.*, 2014).To fill this knowledge gap, we analysed data on injured sea turtles admitted into rehabilitation facilities from 2001 to 2016 in Lampedusa Sea Turtle Rescue Center (Italy) (Fig. 1) for the rehabilitation success, using different factors like type of clinical case, health condition of the animal, and the presence of an experienced surgeon.

Fig. 1. Study area.

MATERIALS AND METHODS

The overall rehabilitation success for all cases presented at the rescue centre was assessed quantitatively by the following formula:

Overall rehabilitation success (%) = (NrecoveredYr / NtreatedYr) × 100

Where NrecoveredYr = number of recovered turtles after medical

treatment per year; NtreatedYr = number of turtles with medical treatment per year. The percentage of rehabilitation has been turned into arcsine (%). Arcsine transformation of data is appropriate for the data on proportions, i.e., data obtained from a count and the data expressed as decimal fractions and percentages; Fig. 2 shows the arcsine percentage of rehabilitation success during the years and the red line represents the best fit obtained with the interpolation line of the curve. The red line was made with a regression line.
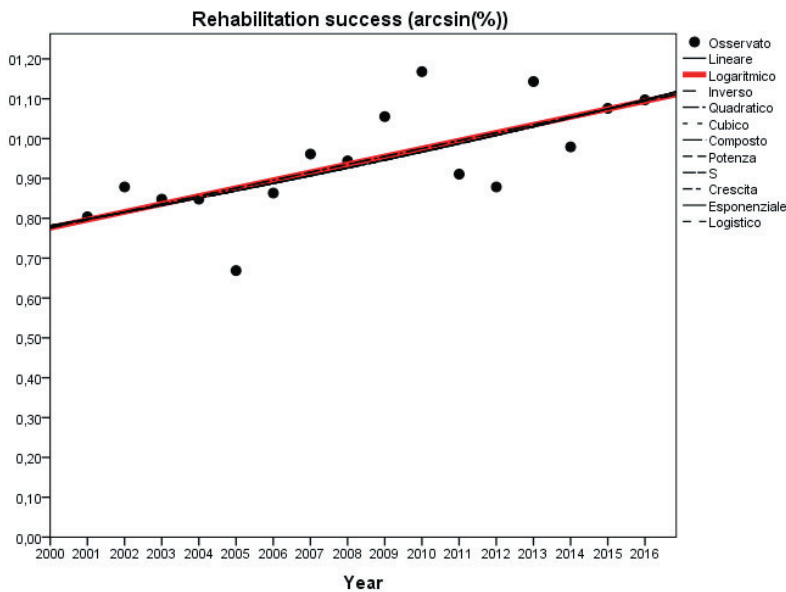

Fig. 2. Arcsine (%) of the rehabilitation success during the years between 2001 and 2016 (n=795). The red line represents the regression line made by interpolation of data.

Each clinical case was first assigned a category, based on its primary manifestation, the criteria for which are represented in Tab. 1. We assigned different colors to the categories to make Fig. 3 more understandable and each clinical case was then identified with a number based on the position of the category in the body. The rehabilitation success for each of these was then calculated to determine which injuries are the most dangerous for sea turtles, using the following formula:

Tab. 1. Assessment criteria for categorizing each clinical case. Colours indicate the category (purple: hook, blue: line, green: fracture, yellow: lesion, black: infection) and each clinical case was then identified with a number based on the position of the category in the body (1: hook in mouth, 2: hook in oesophagus, and so on).

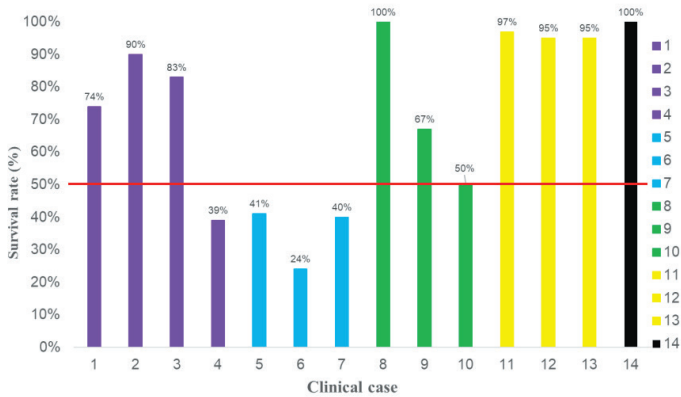| Hook	Line	Fracture	Lesion	14. Infection
1. mouth	5. from mouth	8. flipper	11. flipper	
2. oesophagus	6. from cloaca	9. carapace	12. carapace	
3. stomach	7. from mouth to cloaca	10. head	13. head	
4. intestine				

Fig. 3. Percentage of loggerhead turtles treated with recovery achieved according to the type of clinical case (%). The red line marks 50% (n=928).

Case-specific rehabilitation success (%) = Number of turtles that survived a particular case / Total number of turtles presenting that case

Statistical analysis was performed to compare the result of the treatment (recovery or death), against the health condition of each animal (good, depressed or comatose) by means of Fisher's exact test. The study period was also divided into five subperiods (2001-2003, 2004-2006, 2007-2009, 2010-2012 and 2013-2016) to account for the evolution of surgical techniques and the presence of an expert surgeon with specific experience in sea turtle surgery. A post hoc test of univariate ANOVA was then used to identify the periods with a significant increase in rehabilitation success.

RESULTS AND DISCUSSION

We divided the primary factors that can influence rehabilitation in three areas: clinical case, health condition and presence of an expert surgeon.

Clinical case: Through analysis of the rehabilitation success for each case, it is evident that the presence of a fishing line (in blue) from the mouth (5), from the cloaca (6, Fig. 4), and from the mouth to cloaca (7) were the most dangerous injuries, with a lower than 50% survival rate. Hook in intestine (4) shows a survival rate of only 39%. This is shown above in Fig.3.

Health condition: Health condition was also shown to strongly influence the success of treatments (Tab. 2). The Fisher exact test proves that loggerhead turtles in bad health conditions have a lower probability of survival (P<0,001; n=967), as expected.

Fig. 4. Fishing line hanging from the turtle's cloaca.

Tab. 2. Contingency table: Results of treatment and health condition. Fisher's exact test between the outcome of the treatment and the health conditions upon arrival excluding the "unsolved cases" and the loggerhead turtles with unknown health conditions (P<0,001; n=967).

Contingency table: Results of treatment * health condition					
		Health condition			Total
		good	depressed	comatose	
Results of treatment	recovery	776	44	2	822
	death	36	53	56	145
Total		812	97	58	967

Presence of an expert surgeon: The success of rehabilitation (based on the arcsine%) between the 5 periods identified was evaluated, and revealed a significant increase in success after 2006. We investigate these factors with the post hoc test of univariate ANOVA (P = 0,016; n = 1011) (Fig.5; Tab. 3). The success rate continued to rise over the last 3 periods, when there was the presence of an experienced surgeon, thus suggesting that this factor is of great importance to rescued sea turtle survival.
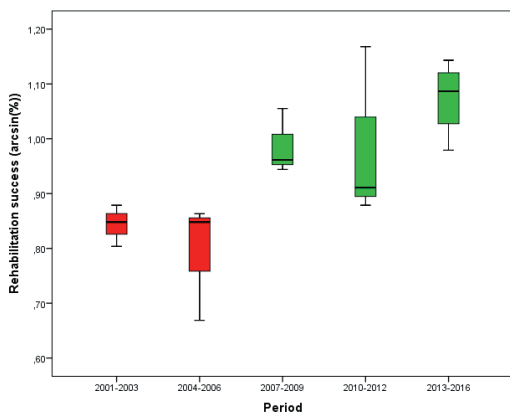

Fig. 5. Arcsine (%) of the rehabilitation success during 5 subperiods (n=1011). The division into periods is given by the evolution of surgical techniques.

Post hoc Test of univariate ANOVA

Dependent variable: Rehabilitation success (Arcsin(%))

LSD

(I) Period	(J) Period	difference between means (I-J)	Standard error	Sig.	Confidence range 95%	
					Lower limit	Higher limit
2001-2003	2004-2006	,05020	,07709	,528	-,1195	,2199
	2007-2009	-,14335	,07709	,090	-,3130	,0263
	2010-2012	-,14234	,07709	,092	-,3120	,0273
	2013-2016	-,23033*	,07211	**,009**	-,3890	-,0716
2004-2006	2001-2003	-,05020	,07709	,528	-,2199	,1195
	2007-2009	-,19355*	,07709	,029	-,3632	-,0239
	2010-2012	-,19254*	,07709	,030	-,3622	-,0229
	2013-2016	-,28053*	,07211	**,003**	-,4392	-,1218
2007-2009	2001-2003	,14335	,07709	,090	-,0263	,3130
	2004-2006	,19355*	,07709	**,029**	,0239	,3632
	2010-2012	,00101	,07709	,990	-,1687	,1707
	2013-2016	-,08698	,07211	,253	-,2457	,0717
2010-2012	2001-2003	,14234	,07709	,092	-,0273	,3120
	2004-2006	,19254*	,07709	**,030**	,0229	,3622
	2007-2009	-,00101	,07709	,990	-,1707	,1687
	2013-2016	-,08799	,07211	,248	-,2467	,0707
2013-2016	2001-2003	,23033*	,07211	**,009**	,0716	,3890
	2004-2006	,28053*	,07211	**,003**	,1218	,4392
	2007-2009	,08698	,07211	,253	-,0717	,2457
	2010-2012	,08799	,07211	,248	-,0707	,2467

*. The average difference is significant at the 0.05 level

Tab. 3. Univariate ANOVA post hoc test on the success of rehabilitation in the five periods. Significant outcome are in bold.

CONCLUSION

This study confirm that lines inside a loggerhead turtle's body result in high mortality, higher than the presence of hooks and this is evident from Fig. 3, The only exception is of hook in intestine, because the presence of the hook in this position must involve the presence of the line in all cases. In fact Professor Di Bello A. has shown in his studies how the presence of a line determines a higher mortality than the presence of only ahook. In fact, surgery of the lower digestive tract is certainly more challenging and further complicated by the serious injuries that hooks and lines often cause in the stomach and intestine, while the surgical approach for the extraction of hook from the oesophagus is relatively easy (Di Bello *et al*., 2010). In several cases single or multiple intestinal lacerations were detected, caused by the pull of the lines, in other cases the surgeon performed enteroctomy of a long section of intestine because of lines injuries (Di Bello *et al*., 2010). Moreover health conditions can have a great influence on rehabilitation success, as we expected. We have seen that loggerhead turtles that show a higher mortality are those that present bad health conditions on arrival (depressed and comatose). Finally we noticed that, especially, the increase in the knowledge of surgical techniques over the years and therefore also the support of an expert surgeon have certainly determined an increasing success in turtle rehabilitation, for turtles have a complex anatomy and all surgical operations require a lot of experience on the part of the operator.

TAKE-HOME MESSAGE: The conservation status of sea turtles has been steadily improving during the last ten years; as a reason for this, we have witnessed an increase in activities aimed at the safeguarding and protection of these species. The role of rescue centers for sea turtles should be to raise public awareness, and therefore of actors in the tourism industry, of the issues concerning the possible extinction of sea turtles.

ACKNOWLEDGMENTS

Received April 1, 2019

REFERENCES

Allen, L.K., 2000: Protected species and New England fisheries: an overview of the problem and conservation Strategies. Northeast Nat **7**, 411–418.

Bagarinao, T.U., 2011: The sea turtles captured by coastal fisheries in the northeastern Sulu Sea, Philippines: documentation, care and release. Herpetological Conservation and Biology **6**, 353–363.

Baker, L., Edwards W. & Pike D.A., 2015: Sea turtle rehabilitation success increases with body size and differs among species. Endangered Species Research **29**, 13-21.

Bentivegna, F., Cirino P. & Toscano, A., 1993: Care and treatment of loggerhead sea turtles from the Gulf of Naples, Italy. Marine Turtle Newsletter, **61**, 6-7.

Casal, A.B. & Orós J., 2009: Plasma biochemistry and haematology values in juvenile loggerhead sea turtles under - going rehabilitation.Vet Record, **164**, 663–665.

Casale, P., Freggi D. & Rocco M., 2008: Mortality induced by drifting longline hooks and branchlines in loggerhead sea turtles, estimated through observation in captivity. Aquatic Conservation: Marine Freshwater Ecosystem **18**, 945-954.

Casale, P., 2011: Sea turtle by-catch in the Mediterranean. Fish and Fisheries, **12**, 299-316.

Casale, P., Freggi D., Paduano V. & Oliverio M., 2016: Biases and best approaches for assessing debris ingestion in sea turtles, with a case study in the Mediterranean. Marine Pollution Bulletin, 1-12.

Di Bello, A., Freggi D. & Valastro C., 2010: Surgical extraction and treatment of injuries caused by fishing hooks and lines in the digestive tract of sea turtles: case histories from 2005 to 2009. Proceedings of the 30th annual symposium on sea turtles biology and conservation, Goa (India), 27-29.

Feck, A.D. & Hamann M., 2013: Effect of sea turtle rehabilitation centres in Queensland, Australia, on people's perceptions of conservation. Endangered Species Research, **20**, 153–165.

Ferraro, P.J. & Pattanayak S.K., 2006: Money for nothing? A call for empirical evaluation of biodiversity conservation investments. PLOS Biology, **4-e105**, 482-488.

Lazar, B., Margaritoulis D., Tvrtković N., 2004: Tag recoveries of the loggerhead sea turtle *Caretta* caretta in the eastern Adriatic Sea: implications for conservation. Journal of Marine Biology Association of the United Kingdom, **84**, 475-480.

Mestre, F., Braganca M.P., Nunes A. & dos Santos M.E., 2014: Satellite tracking of sea turtles released after prolongedcaptivity periods. Marine Biology Research, **10**, 996–1006

RAC/SPA, 2004: Guidelines to improve the involvement of marine rescue centers for marine turtles. RAC/SPA, Tunis, 48 pp.

Tribe, A. & Brown P.R., 2000: The role of wildlife rescue groups in the care and rehabilitation of Australian fauna. Human Dimension of Wildlife, **5**, 69–85.

Wimberger, K., Downs C.T. & Boyes R.S., 2010: A survey of wildlife rehabilitation in South Africa:Is there a need for improved management? Animal Welfare, **19,** 481–499.

SUMMARY

Determination of the factors that might have influenced the rehabilitation of *Caretta caretta* in the Lampedusa Sea Turtle Rescue Center between 2001-2016

C. Roldi & D. Freggi

Over the last few decades, the status of sea turtles and the need for their protection have increasingly captured the interest of citizens, and the number of sea turtle rescue centers is increasing worldwide, but especially in Italy, where we count more than 25 first aid stations.

The Lampedusa Sea Turtle Rescue Center started its activity in 1990, and in this paper we analyze data from 2812 loggerhead turtlesrescued by 2016. Here we analyse which factors might have affected the rehabilitation success of the injured sea turtles hosted in our Center. We underline the following factors: type of clinical case, animal's health condition and the presence of a qualified surgeon.

For the first factor we estimated the percentage of survival animals with the following clinical cases (n=928): infections, fin/carapace/head fractures, fin/carapace/head wounds, hook in oesophagus/intestine/stomach/mouth, fishing line from mouth/cloaca, fishing line from mouth and cloaca; five of the analysed clinical cases show rehab success below 50% (head fracture, fishing line from cloaca/mouth/mouth and cloaca, hook in intestine).

For the second factor we estimated the outcome of therapies (recovery achieved/death) and health condition (good health condition/depressed/comatose) using the Fisher exact test. The Fisher test confirmed how health condition can significantly affect sea turtle rehabilitation success (Fisher test=369,894; d.f.=2; P‹0,001; n=967).

For the last factor, we divided the study period into five subperiods (2001-2003, 2004-2006, 2007-2009, 2010-2012, 2013-2016) based on the evolution of surgical techniques and the presence of an expert surgeon with direct experience of sea turtle surgery; with post hoc test of univariate ANOVA investigation, we confirm significantly the value of the experience of professionals involved (P= 0,016; n = 1011).Bycatch and health condition appear to significantly influence rehab success and the presence of a competent surgeon is radically responsible for an increase in the survival of loggerhead turtles,as expected.