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Development of an environmental enrichment programme: A case study with a white Bengal tiger (*Panthera tigris bengalensis*) and a jaguar (*Panthera onca*) at Moscow Zoo

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Abstract

Zoos are urged to implement enrichment programmes that include constant feedback to increase efficacy. However, such work is time consuming for zookeepers. The goal of this case study was to establish an enrichment programme in Moscow Zoo that could be used by keepers with minimal effort. In this brief study, an enrichment programme was established for one female white Bengal tiger (*Panthera tigris bengalensis*) and one female jaguar (*Panthera onca*). Observations were recorded from February through March 2015. The effects of three enrichment regimes were evaluated: Baseline (routine husbandry: familiar or novel items once or twice a week) compared with two novel intensive regimes: Regime 1 (enrichment provided every day) and Regime 2 (enrichment provided every other day). Two simple methods were used to evaluate the effects of regimes: the "multi-point scan" method where animals' behaviour was recorded 6 times a day by the keepers as they passed the exhibits during their working day, and "SPIDER indirect scales". It was found that the use of both methods for documenting behaviour improved the accuracy of evaluations. During Regimes 1 and 2, behaviour directed at enrichment increased for the tiger and jaguar, but changes in general activity were identified only for the tiger. Consequently, the keepers were able to develop an enrichment programme, including the collection of objective empirical data in a time-efficient manner. It is therefore proposed that zoological institutions use enrichment programmes that integrate both "SPI" and "DER" steps into daily work.

Background

Environmental enrichment is the main tool for increasing behavioural opportunities and provision of choice in the captive animals' environment, with the aim of maintaining their welfare (Maple and Perdue 2013). The classification of enrichment methods and the creation of an enrichment calendar have been developed to regulate practice and to provide animals with different types of enrichment (Bloomsmith et al. 1991; Maple and Perdue 2013). To assess whether enrichment is effective at achieving its specific goal, for example, increasing normal activity or reducing undesirable behaviour (Young 2003; Melfi 2009; Maple and Perdue 2013), an process has been developed which includes all the necessary steps of a successful enrichment programme: Setting goals, Planning, Implementation, Documentation, Evaluation and Re-adjustment (SPIDER) (Mellen and MacPhee 2001). However, in practice, enrichment provision often includes only the first three stages of SPIDER, "SPI" (Alligood and Leighty 2015), probably because of keepers' time limitations. Often, methods of behaviour data collection are time-intensive, such as the "time budget" approach (Watters et al. 2019). However, systematic feedback and evaluation of enrichment efficacy is essential (Hoy et al. 2010). In response, a set of simple formalised approaches and methods has been developed (Mellen and MacPhee 2001; Plowman 2012; Margulis and Westhus 2008; Whitham and Wielebnowski 2009; Quirke and O'Riordan 2012), which allow zoo employees to quickly

Table 1. The total number of observations for the female tiger and the female jaguar for the study. The SPIDER indirect scale was not used during the Baseline regime and Regime 2 (days without enrichment, EE) because of the low numbers or absence of new enrichment events (indicated as - in table).

	The female tiger				The female jaguar			
Method of observation	Baseline	Regime 1	Regime 2		Baseline	Regime 1	Regime 2	
			Days with EE	Days without EE			Days with EE	Days without EE
Number of scans for "multi-point scans" method	93	71	47	43	91	69	47	43
Number of assessments for SPIDER indirect scale	-	12	7	-	-	12	7	-
Number of observation days	15	12	7	7	15	12	7	7

collect useful data about reactions to enrichment and to guide the enrichment programme.

In Moscow zoo no formal enrichment evaluation over a continuous basis is undertaken by keepers; though the science department engage in these activities. The aim of this study therefore, was to empower keepers to establish enrichment programmes for the zoo's felids, which integrate both "SPI" and "DER" steps.

Action

This study took place from February through to March 2015 at Moscow Zoo, Russia, and was conducted in accordance with the guidelines for the treatment of animals in behavioural research and teaching (Animal Behaviour 2012). The subjects of this study were an 18-year old female white Bengal tiger (*Panthera tigris bengalensis*) and a 20-year old female jaguar (*Panthera onca*). The tiger was housed in an outdoor exhibit that measured approximately 120 m^2 and an adjoining indoor exhibit of 45 m^2. The jaguar was kept in two adjacent indoor enclosures measuring 60 and 45 m^2. All enclosures had wood platforms, rocks, logs, hanging plastic objects and plastic barrels. Both animals were routinely exposed to a variety of food, odours and physical enrichment on a regular schedule: one or two familiar methods (previously used items and novel ones) and sometimes novel techniques were provided once or twice a week; this was termed the Baseline regime for the study. In this study, new enrichment programmes were created which included all the six steps of the SPIDER framework (Mellen and MacPhee 2001):

Setting goals

To stimulate species-typical behaviour, increase activity levels and exploratory behaviours in the jaguar and tiger.

Planning

Two intensive enrichment regimes were introduced, comprising Regime 1 (enrichment items given every day) and Regime 2 (enrichment items given every other day, days with enrichment [Regime 2: with EE] and days without enrichment [Regime 2: without EE]). Regime 1 and 2 provided novel items more frequently and on a truly random basis (unpredictable combinations and sequences of enrichment items with no repetition) compared to Baseline.

A random number generator in a Microsoft Excel spreadsheet was used (Table 2) to allocate random combinations of enrichment items within Regime 1 and 2. The random generator allowed

Table 2. A random number generator was employed to choose enrichment items which were incoporated into an enrichment calendar; various types of enrichment were available to be used.

Random numbers	Random foraging enrichment items	Foraging	Random physical enrichment items	Physical	Random olfactory enrichment items	Olfactory
Random number	meat in a plastic barrel	meat in cardboard boxes	two traffic cones fastened together with fire hose	snowman with a hessian sack and hay inside	hessian sack with the smell of hoofstock faeces	essential oils sprayed on a cardboard box
Random number		popsicle		cardboard box with hay inside		hessian sack with the smell of hoofstock faeces
Random number		artificial prey (plastic barrel with cardboard tube legs and neck with cardboard box at the top and meat inside)		plastic barrel		straw bedding from guinea pig enclosure in a cardboard box
Random number		meat in a plastic barrel		plastic barrel with Christmas tree inside		paper bags of meal
Random number		meat in a hessian sack hung from furnishings		two traffic cones fastened together with fire hose		essential oils sprayed on a plastic object

Table 3. Exemplar of an enrichment calendar.

Data	Foraging	Physical	Olfactory	Notes
Monday	meat in a plastic barrel	two traffic cones fastened together with fire hose	hessian sack with the smell of hoofstock faeces	*make artificial prey for tomorrow
Tuesday	meat in cardboard boxes	*artificial prey (plastic barrel with cardboard tube legs and neck with cardboard box at the top and meat inside)	straw bedding from guinea pig enclosure	

keepers to select one enrichment item (Table 2) per category (foraging, physical, olfactory), every day, thereby creating an enrichment calendar (Table 3) in a time-effective manner. If the programme included a method that needed to be applied at a specific time, then a note was made in the calendar.

Implementation

The animals were provided with enrichment according to the enrichment calendar during Regime 1 and 2. Enrichment items and sequences were identical for both animals.

Three keepers who had been working with these animals for several years made observations from 1100 to 1700, when animals had access to enclosures. Keepers were instructed on assessment methods and the ethogram (Table 4), and how to subsequently analyse the data.

Two assessment methods were used. The "multi-point scan" method which is comparable to intensive sampling regimes (Margulis and Westhaus 2008), but is relatively simple, in which keepers make a rapid behavioural observation (scans) when they pass the exhibit during their daily routines (Canino and Powell 2010). The multi-point scan method is not sensitive to rare behaviours and may lead to misinterpretation of the effect of an enrichment programme (Quirke and O'Riordan 2012). Therefore, a second assessment method, the "SPIDER indirect scale", was also used. The SPIDER indirect scale notes three levels of animal involvement with the enrichment: 1 = no evidence of interaction; 2 = moderate evidence of interaction; 3 = significant evidence of interaction. The SPIDER indirect scale was not used during the Baseline regime because of the low numbers of new enrichment events (enrichment items were provided only twice for the whole Baseline regime). In addition, it is difficult to assess the level of interaction with objects that are fixed to the enclosure, for example, the hanging plastic objects or logs. The keepers recorded one score at the end of each day during Regime 1 and 2: with EE.

Table 4. Ethogram for white Bengal tiger and jaguar.

Category	Behaviour
Activity	1. Active – A (walk, run, jump)
	2. Any behaviour directed at enrichment device – BE (sniff, manipulation of an object)
	3. Feeding-related – F (any consumption behaviour)
	4. Grooming, rolling, rubbing – GR
Inactivity	1. Lay down (with or without eye open)
	2. Sit down
	3. Stay
Stereotypy	Pacing (repetitive action of walking back and forth in the same location [Canino and Powell 2010]).
Out of sight	Animal is not visible to observer

Documentation

Keepers recorded data in a custom-made, user-friendly spreadsheet in Microsoft Excel (Table 5A). Simple techniques for objective estimation of enrichment effects were selected, to easily fit into keeper schedules. The following behaviours, including but not limited to walk, run, jump, behaviour directed at enrichment device, feeding-related, grooming, rolling, and rubbing, were documented.

Evaluation

The effectiveness of the three enrichment regimes (Baseline, Regime 1 and 2) for the tiger and the jaguar were subsequently evaluated. Data were manually entered into the spreadsheet and were automatically transformed to percentages, by linking the two spreadsheets: A) raw data reports (Table 5A) and B) table containing simple formulae for transformation of data (Table 5B). Table 5B provides the keepers with information such as the percentage per day or "median %" per regime of each behaviour collected by the multi-point scan method and the SPIDER indirect scale. Median % per period is automatically highlighted at the end of the table (Table 5B).

To determine if the enrichment goal had been reached (to increase activity levels and exploratory behaviours), non-parametric tests were used to compare behaviour between the three different enrichment regimes; however, it is not expected that our keepers use statistical analyses on a regular basis. A Friedmann ANOVA was carried out to test if behaviour was influenced by enrichment regime. A Wilcoxon signed-rank test with 'False Discovery Rate' (FDA) correction (Benjamini and Hochberg 1995) was performed to determine significant pair-wise relationships. A Spearman rank correlation was used to assess habituation to enrichment: correlation between 1) a number of enrichment days (Regime 1 and 2: with EE) and 2) behaviour directed to i) enrichment (multi-point scan method) or ii) indirect evidence (SPIDER indirect scale). The alpha level for statistical significance was $P<0.05$ for all tests. Statistica 6.1 (StatSoft) and Microsoft Excel 2010 were used for all analyses. One day became a unit of analysis. All graphs are built in Excel and Statistica.

Table 5. Exemplar of the spreadsheet for behavioural observations and an assessment of animals' involvement with enrichment.

Table A: Raw data														
Data	Animal	Period	Enrichment items	Multi-point scan*							SPIDER scale			
				∑ of scans	Activity				IN	ST	OUT	Indirect evidence		
					A	BE	F	GR				1	2	3
Table B: %														
Notes					Median % per period							Indirect evidence (median) %		

* See Table 4 for decoding behaviour collected by "multi-point scan" method.

Re-adjustment

Re-adjustment of the existing enrichment programmes for the tiger and jaguar of Moscow zoo were considered, following a discussion of the results, as given below.

Consequences

During the study, keepers conducted six scans per day to record behaviour (Table 4) and reached a level of at least 80% agreement between observers. A total of 254 scans for the tiger and 250 for the jaguar were analysed. For the SPIDER indirect scale, a total of 19 points for each animal were collected (Table 1).

Tiger

Using the multi-point scan method, enrichment treatment had a significant effect on behaviour directed at enrichment device (hereafter "BE") (Friedman's two-way ANOVA, x^2=10.42, d.f.=3, P=0.01), but not on overall activity (x^2=2.83, d.f.=3, P=0.42). Although trends were apparent, multiple comparisons with FDA correction revealed no significant difference between enrichment regimes both for activity or BE, probably due to the small sample size.

During Regime 1, the tiger had an increase in median level of activity from 66.67 to 80% (Wilcoxon signed rank tests, Z=2.11; P=0.18) (Figure 1), and an increase in BE from 0 to 18.33% (Z=−2.36; P=0.08) (Figure 2). BE was observed on only one of 15 days during the Baseline period, which amounted to 1.43% (mean) of this period.

Regime 2 revealed a reduction in the median level of activity to the Baseline level (Regime 2: with EE, 55.5% (Z=0.67; P=0.59) and Regime 2: without EE, 50% (Z=1.18; P=0.48)). During Regime 2: with EE, BE was at approximately the same level as in Regime 1 (Z=0.36; P=0.71), which was higher than Baseline (BE: Z= 2.02; P=0.08). There was no interaction with old enrichment devices in the days without enrichment (Regime 2: with EE, 16.6% and Regime 2: without EE, 0%; Z=1.82; P=0.08). There were changes in the time spent performing the activity, including BE, between Regime 1 and Regime 2: without EE (80 vs. 50% for activity level: Z=1.86; P=0.18; and 18.33 vs. 0% for BE: Z=1.82; P=0.08).

During Regime 1, there were 91.67% (n=12) "positive" evaluations based on the SPIDER indirect scale (scores of 2 and 3) that reflect physical contact with enrichment items (Figure 3A). During Regime 2: with EE, 100% evaluations indicated physical contact with enrichment items.

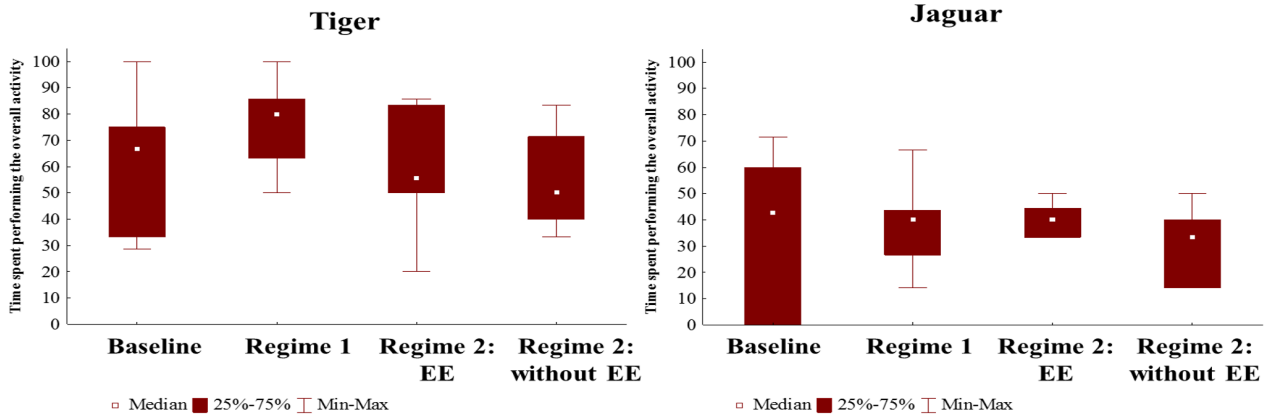

Figure 1. Proportion of time spent performing activity (walk, run, jump, behaviour directed at enrichment device, feeding-related, grooming, rolling and rubbing) by the female tiger and the female jaguar (data are presented as the daily median) under different enrichment regimes: Baseline: enrichment one to two times per week (n=15); Regime 1: daily enrichment (n=12); Regime 2: enrichment every other day (n=14). Data were collected using the "multi-point scans" method.

Habituation to novel enrichment regimes was not observed (Figure 3A); calculated by correlating the number of days enrichment was provided against BE: using multi-point scan data, Regime 1 (Spearman's rank correlation R=0.01; P=0.97), Regime 2: with EE (R=−0.09; P=0.86); using SPIDER indirect scale data: Regime 1 (R=−0.39; P=0.21), Regime 2: with EE (R=−0.15; P=0.73) (Figure 3A).

Jaguar

Using the multi-point scan data, there was a significant effect of enrichment regime on the jaguar's BE (x^2=7.78, d.f.=3, P=0.05), but no impact on overall activity (x^2=4.04, d.f.=3, P=0.26), and no significance was found after post-hoc tests with FDA correction.

The median level of activity of the jaguar remained approximately the same, 42.86% in the Baseline, 40% during Regime 1 and 2: with EE and a slight decrease to 33.33% during Regime 2: without EE (Figure 1). The jaguar interacted with enrichment items during the Baseline at an average level of 8.99%. During Regime 1, the median level of BE increased by 20% (Baseline: 0%, Regime 1: 20%, Z=−1.60; P=0.22) (Figure 2).

In Regime 2: with EE, BE remained at 20%, as in Regime 1. However, on days of Regime 2: without EE, interaction with old objects almost completely stopped (Regime 1, 20% and Regime 2: without EE, 0%, Z=2.20; P=0.12; Regime 2: with EE, 20% and Regime 2: without EE, 0%, Z=2.02; P=0.12). In addition, the jaguar was found to stereotype (mean: 2%) in Regime 2: with EE and without EE.

In contrast, 100% of assessments obtained by the SPIDER indirect scale indicated physical contact with enrichment items during both Regime 1 and 2 (Regime 1, R=−0.26; P=0.88; Regime 2, R=0.00; P=1.00). This indicates no habituation to novel regimes in the jaguar. It is likely that indirect assessments in some cases are overstated, but this method nevertheless provides insightful data. According to the multi-point scan method, however, there was a negative correlation between the number of enrichment days and BE (Regime 1, R=−0.69; P=0.03), with the tendency of habituation in Regime 2: with EE (R=−0.56; P=0.18) (Figure 3B). In general, the two novel enrichment regimes have no long-term effect on the level of BE of the jaguar.

Interpretation

Zoos and aquarium associations encourage modern zoos to use decision-making processes to objectively monitor individual animal welfare (EAZA 2014; Mellor et al. 2015). This study evidences how a time-efficient enrichment programme was established. Both novel intensive regimes were associated with more behaviour directed at enrichment; however, this was statistically insignificant. This may be due to the small sample size, therefore indicating a need for further research. Despite identical enrichment items and sequences, responses of the tiger and the jaguar differed. The jaguar demonstrated pacing for an average of 2% of its overall activity budget in Regime 2, which most likely indicates an artifact. The overall normal activity of the jaguar did not change during the study. In contrast, the tiger exhibited no undesirable behaviour, and its activity displayed clear, although non-significant, changes between the regimes. Their different reactions to the same enrichment regimes can be explained by the observation that they exhibit differences in their overall activity budgets during the Baseline regime. This reaffirms that welfare concerns an individual animal's state at a particular time (Hill and Broom 2009) and that responses to enrichment can differ (e.g. Kolter and Zander 1995; Shepherdson et al. 2004), therefore indicating the need to develop individual enrichment programmes.

Felids can quickly habituate to novel enrichments, so in zoos they receive varying types of enrichment that have been shown to encourage diversity and occurrence of natural activity, as well as a decrease in stereotypic behaviour (Mellen and Shepherdson 1997; Bashaw et al. 2003; Szokalski et al. 2012). In this study, animals were provided with food, physical and olfactory items to give them more choice and control over their environment, thus helping to elicit natural behaviours, such as flehmen, sniffing, dragging and pulling objects, and preventing habituation to their environment. Habituation to enrichment was found for the jaguar using the multi-point scan method, whereby a steady decline in behaviour directed at enrichment during Regime 1 was observed. It was shown that the multi-point scan method has a small error for the common forms of behaviour, those that occurred 15% and more in the activity budget (Margulis and Westhaus 2008). During the novel intensive regimes, the average (median) level of

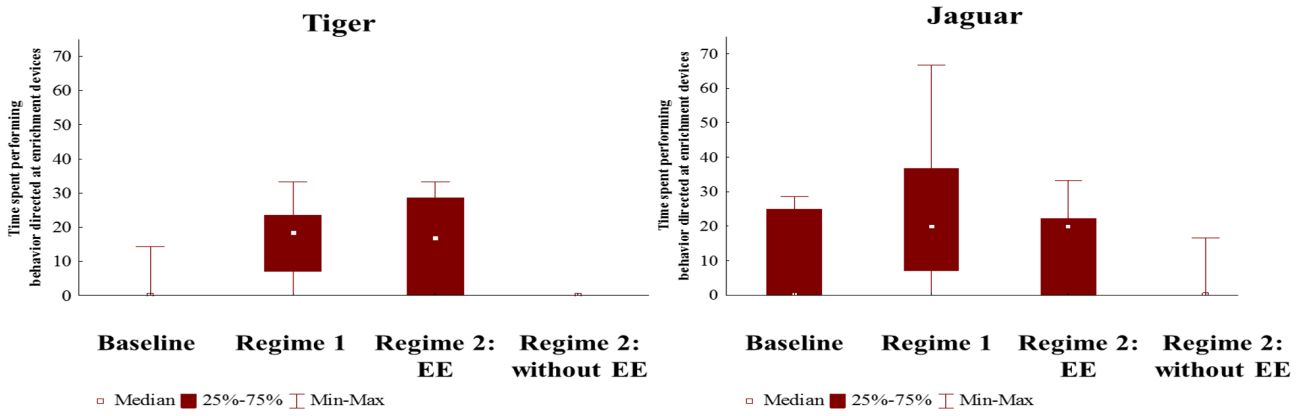

Figure 2. Proportion of time spent performing behaviour directed at enrichment devices of the female tiger and the female jaguar (data are presented as the daily median) under different enrichment regimes: Baseline: enrichment one to -two times per week (n=15); Regime 1: daily enrichment (n=12); Regime 2: enrichment every other day (n=14). Data were collected using the "multi-point scans" method.

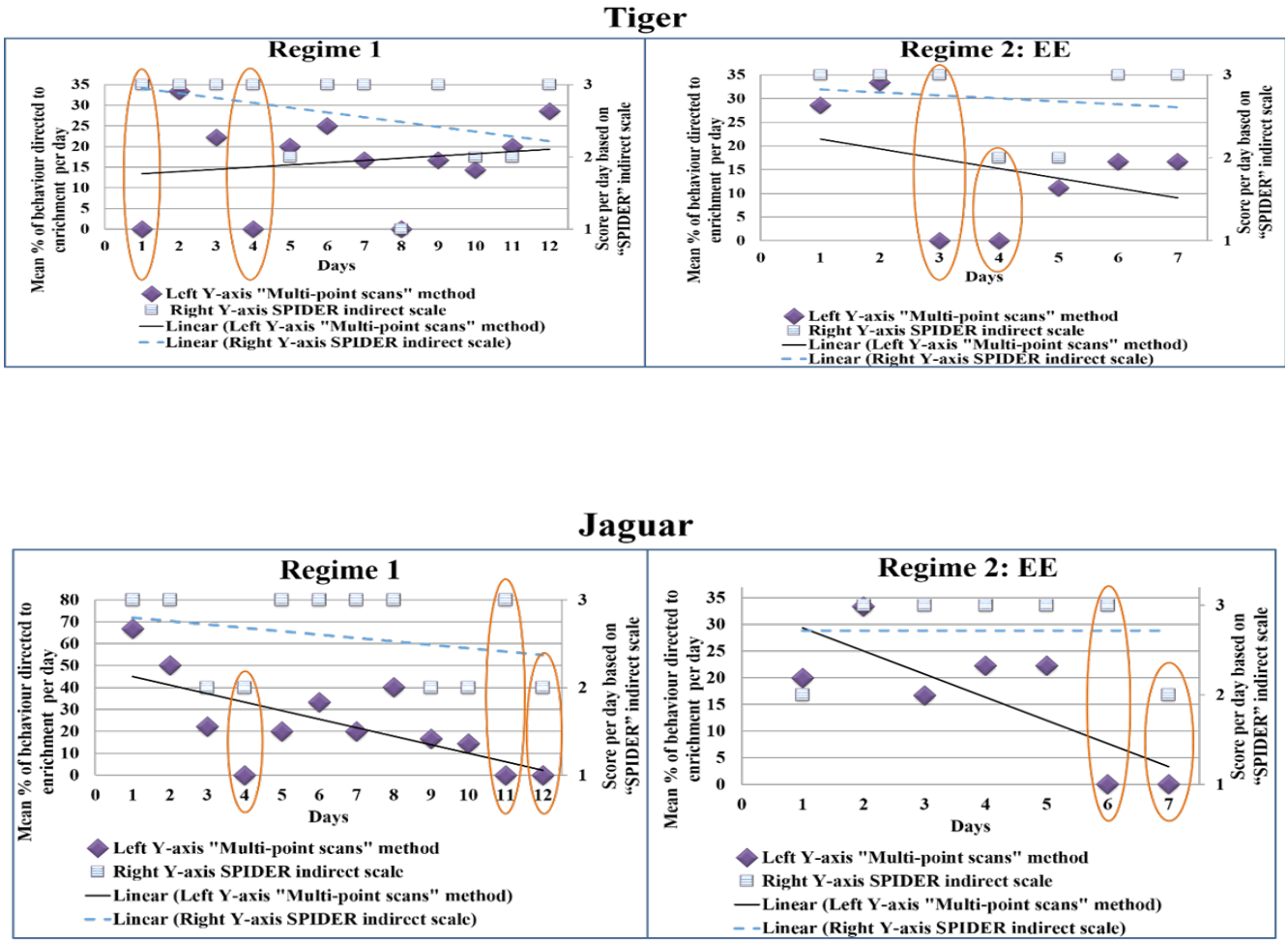

Figure 3. Habituation of the female tiger (A) and the female jaguar (B) to novel enrichment regimes. Analysis was conducted using the two methods: 1. Purple rhombus: data were collected using the "multi-point scans" method (mean percentage of BE per day); 2. Stripped square: data were collected using "SPIDER" indirect scales (1 = no evidence of interaction; 2, 3 = moderate or significant evidence). Highlighted by ellipse, the gap of the "multi-point scans" analysis that was detected using indirect scales.

behaviour directed at enrichment was in the range of 16 to 20% for both animals. However, this level was likely to be even higher, based on an analysis of the complementary method. As predicted, the SPIDER indirect scale detected some gaps in the multi-point scan observations, which include evidence of the animals' interactions with enrichment items. The second method enabled the collection of 100% of the data for this form of behaviour based on changes in objects (destructible and not fastened) that were provided to the animals within the study. It is proposed that the combination of these two methods contributes to a better understanding of effects on animal behaviour of enrichment and enables an evaluation of its effectiveness.

Keepers were involved in all six stages of the enrichment programme, "SPIDER", and demonstrated the potential to maintain the whole process by themselves. Although not easy, it only involved an additional 15–30 minutes per day. Potentially, keepers may adapt the enrichment programme, focusing on the percentage of time that the animal demonstrates normal and pathological activities, behaviour directed at enrichment device and SPIDER indirect evidence. All these characteristics can be automatically calculated and graphically displayed in Excel. Moreover, it is possible to establish a database of enrichment in individual animals that can provide timely feedback for daily management decisions. This would enable keepers to receive regular reports on behaviour in an accessible form and encourage them to work closely with an animal behaviour expert to interpret and analyse the data.

The current study presents a way to simply and rapidly enhance the efficacy of enrichment, similarly to those of Margulis and Westhaus (2008) and Canino and Powell (2010). This can help develop enrichment in zoos via the use of simple tools, which could increase the objectivity of decisions made regarding environmental enrichment.

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