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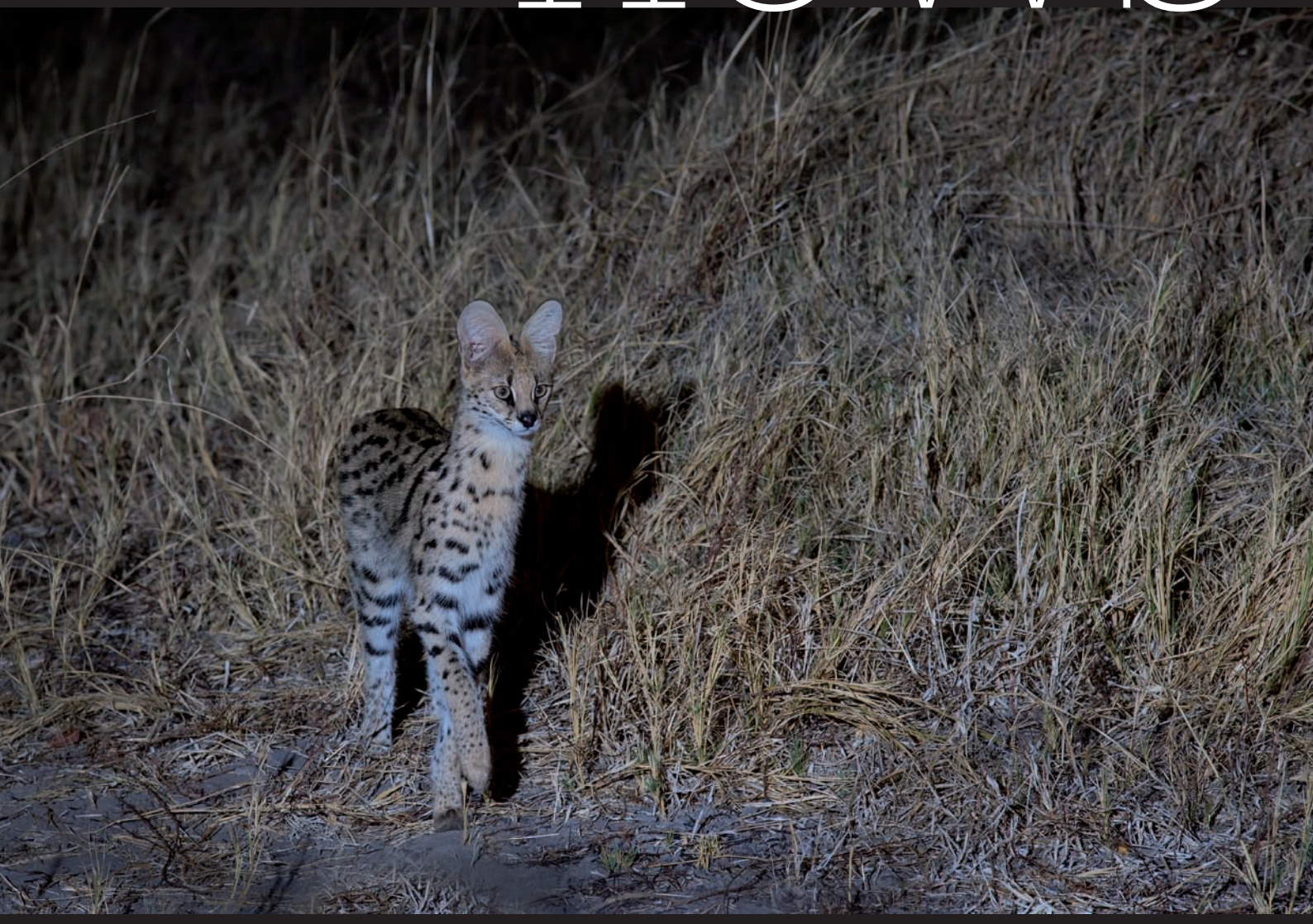

SPECIES SURVIVAL COMMISSION

CAT SPECIALIST GROUP

CATnews is the newsletter of the Cat Specialist Group, a component of the Species Survival Commission SSC of the International Union for Conservation of Nature (IUCN). It is published twice a year, and is available to members and the Friends of the Cat Group.

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Original contributions and short notes about wild cats are welcome
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Stability of tigers in Chitwan National Park, Nepal

Tiger *Panthera tigris* monitoring using radio-telemetry, pugmark tracking and camera trapping was conducted for four decades in an area of approximately 100 km² in the western part of Chitwan National Park, Nepal. The aim was to record the life history, longevity and reproductive status of the resident breeding tigers. From 1985 to 2015, the data shows a density of six breeding females / 100 km² and considerable disparity in reproductive success for male and female tigers. Seven long-lived females (12-17 years) produced a mean of 5.14 litters, yielding an average litter size of 2.89. Nearly 60 percent of the cubs survived up to the age of dispersal. Such high reproductive success and constant number of breeding females are the contributing factors in the stability of the Chitwan tiger population.

Chitwan National Park CNP, a UNESCO World Heritage Site, was established in 1973 largely to protect two iconic endangered species, the greater one horned rhinoceros *Rhinoceros unicornis* and the Bengal tiger *Panthera tigris tigris*. Prior to the park's establishment, most of the area was a Rhinoceros Sanctuary, which was created in 1962. A force of armed guards, called the Gaida Gusti (Rhino Patrol), manned a series of guard-posts throughout the area to prevent poaching. However, nothing was done to curtail the overgrazing by large numbers of domestic cattle and buffaloes. Large livestock numbers simply compensated for decline in deer numbers. With less natural prey available, tiger numbers were also down.

When the park was created, one of the first priorities was the control of illegal domestic livestock grazing. This task was tackled energetically by Tirtha Man Maskey, the first Chief Warden of CNP. Additionally, in 1975, a contingent of the Nepal Army was stationed inside the Park to protect rhinoceros and tigers but also to deter illegal human activities within the park. Livestock were rounded up and kept in enclosures at the guard posts until the owners paid a fine for their release. It took almost three years, but eventually domestic livestock grazing was controlled. The result was that deer numbers rose and the tiger numbers followed suit. However, very little was known about tiger biology, behaviour, reproduction, dispersal, movement/activity pattern, and habitat requirements that could assist the park management for better protection. To address this lack of knowledge, the Smithsonian Nepal Tiger Ecology Project began in 1973 and continued through 1980. For the first time, radio-telemetry was used on tigers to monitor the movement and activities of individual tigers. One of the major findings of the project was that breeding tigers maintain exclusive home ranges defined as territories (Sunquist 1981). Females compete for resources to establish exclusive territories to maintain themselves and to raise their offspring. Males compete for reproductive females, with successful ones establishing territories that monopolise several females (Sunquist 1981).

In 1980, McDougal was made a Smithsonian Research Associate to conduct a long term tiger monitoring LTTM project as a follow up to the earlier Smithsonian Studies in the 1970s. The objective was to gain a long-term perspective on the population dynamics, life histories, and reproduction, including cub survival to age of dispersal. In this paper, we analyse the data collected during this project to determine the life histories of the resident

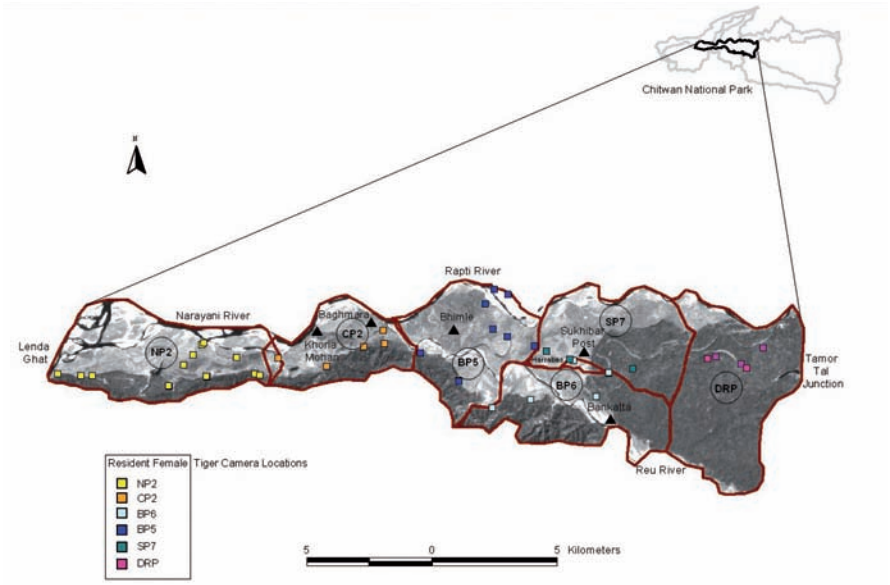

Fig. 1. Study area with camera trapping locations and territories of six breeding resident females during the season 2013-14.

breeding tigers and their reproductive contribution to the population.

Study area

CNP (~ 950 km²) is a dun, or interior valley, between the two outermost ranges of the Himalayas, the Mahabharat and the Siwaliks, in south central Nepal. Rich alluvial soils support a diverse floodplain covered with tall grassland and riverine forest, which constitute 30% of the park; 70% consists of upland Sal forest. The study area of approximately 100 km² contains grassland, riverine forest, and the lowland Sal forest. The area is bounded by Tamor Tal Junction, on the east, and Lenda Ghat, on the west; between the Rapti and Narayani Rivers, on the north, and the Reu River and the base of the Someswar Hills on the south (Fig. 1). The park contains large populations of prey species for tigers: sambar, spotted deer, hog deer, wild boar, and gaur. The CNP is part of the larger Chitwan-Parsa-Valmiki Tiger Conservation Unit that has a regional priority of tiger population persistence over a long term (Sanderson et al. 2006). The large tiger population of Chitwan is the mainstay of this Conservation Landscape.

Methods

Ever since the creation of the park, McDougal and colleagues have been monitoring resident breeding tigers in the same study area. An adult female was considered a resident if she was accompanied by cubs or juveniles or if she was recorded in the same locality in two consecutive seasons. Monitoring season was between mid-September and mid-June. We used three different tiger monitoring methods: radio-telemetry, pugmarks and camera trapping. Radio-telemetry was used between 1975 and 1980, when each resident individual became an identification number based on the radio frequency (Sunquist 1981). During this time a reliable system of identifying tiger by their tracks (pugmarks) was developed and tested (Smith et al. 1999). We monitored radio-collared tigers until the last batteries died out and we used pugmark tracking between 1980 and 1995. Individual tigers were monitored by diagnostic features found on any of their four pugmarks (McDougal 1999). As a cross check on pugmark identification, we used camera trap photography on ad hoc basis.

Finally, between 1995 and 2015, we used systematic camera trapping. We first used the Trailmaster camera traps (Goodson Associates, Kansas, USA) and after 2008 we used digital passive infrared motion detecting Moultrie game cameras (Moultrie Feeders, Alabaster, Alabama, USA). We divided the study area into 4 blocks (range ~ 17 to 29 km²) that were successively camera trapped each season. We equipped each block with 4 - 10 camera locations spread 1 and 1.5 km apart. Each block was trapped 1-3 times per year and for 10-27 trap nights. We set up two cameras in each location, along roads, trails, and other frequent tiger travel routes. Two cameras facing each other were used to simultaneously photograph both sides of an animal to ensure a complete identification of an individual tiger. We used a handheld Garmin eTrex (Garmin International Inc., KS, USA) global positioning system GPS receiver to record the location of each camera trap.

We identified individual tigers from the pugmarks (unique features from any of the four feet) and pictures using their unique stripe patterns and facial marking (McDougal 1977). We then gave names to the identified tigers and used the abbreviation in the database (Table 1, Supporting Online Material SOM Table T1a, b). We also recorded the number of cubs born to the resident females, when first accompanying them approximately at 3 months of age and monitored them up to the age of dispersal. Finally, we mapped the territory of each breeding female based on the radio-telemetry locations, pugmark distribution and camera trapping locations (Fig. 1).

Results

We recorded a total of 34 resident breeding females with 6, 12 and 16 females identified during radio-tracking, pugmark tracking and camera trapping periods respectively (SOM T1 a, b). Five females recorded in previous periods were monitored in the next successive period, where a total of 17 and 21 females were monitored during the pugmark tracking and camera trapping period. The number of resident breeding females (mean = 6.1) ranged from 3-8. The mean numbers of females in each period were: radio-tracking (mean = 3.50), pugmark tracking (mean = 5.87), and camera trapping (mean = 6.35).

Camera trapping period

There were two gaps in data collection in this period. We camera trapped 17 seasons: ten seasons from 1995-2005, five seasons from 2007-2012, and two seasons from 2013-2015, over a total period of 20 years (SOM T1b). Even during the 2 intervals between the 3 periods, we were able to collect data on individual residents, so that we have a complete data set covering 20 years.

During that time we recorded 20 resident breeding females and one post-reproductive one. Likewise, there were 10 resident breeding males. Among these males and females, 146 cubs were recorded belonging to 53 litters. The mean litter size was 2.80.

There was considerable disparity in reproductive success for both sexes. Seven long-lived females (recorded more than 10 seasons; 35% of the total) produced 61% of the young (Table 1). These seven females produced a mean of 5.14 litters during their

lifetimes (range 4-6). The 36 litters were comprised of 104 young, yielding a mean litter size of 2.89. Survival rate to dispersal age was 58%. The seven females reached on average 14.5 years (range 12-17). One male, EB, in his 6 year breeding life, sired 16 litters with 10 different females; five of those were long-lived females who resided in EB's territory concurrently from 1999 through 2001 (Table 1).

Discussion

The most surprising result of our study was the stability of the number of resident females in the area. In 1975, when the park was two years old, there were only three breeding females in the study area. Ten years later, in 1985-86 the number increased to six breeding females. Since then until the present, the number has remained at six, occasionally rising to seven or eight. For example, in 1995-96 the newly established female BP3 replaced her post-reproductive mother JP, reducing the number of females that year from seven to six. The mean density of six breeding female tigers per 100 km² is also supported by previous publication (Barlow et al. 2009). There was a large fluctuation in the numbers of nonbreeding sub-adult and transient tigers, something that is not possible to identify in a single season. As such, more than two consecutive season of monitoring is recommended to differentiate breeding and nonbreeding adults in the population.

For reproduction, the critical resource of a tiger population is its resident reproductive females: their number, stability, density, longevity, and reproductive success. Males are also important. When resident males were stable, cub survival to dispersal was very high (Smith & McDougal 1991). However, during the period of interregnum, infanticide was widespread. Increased rates of infanticide have also been documented in lions, leopards (Packer et al. 2010) and cougars (Packer et al. 2009) following the loss (removal) of resident males.

Both male and female tigers showed considerable disparity in reproductive success, which is also reported by Smith et al. (2010). The longest-lived female produced a significantly higher percentage of cubs and the dominant male produced the majority of the offspring. During the camera trapping period, the three longest-lived females, SP7 (Sukhibar Pothi), LP3 (Lucky Pothi), and CP2 (Chamka Pothi), all lived to the age of 17 years. All three produced litters by the same two males, first EB and then IB. In the process three cases of likely infanticides were reported. SP7 and LP3 lost each one litter of three cubs of EB by IB, but CP2 lost none because there was a three month gap before IB replaced EB. LP3 lost her first litter, an additional two cubs, when EB replaced NB.

CP2 and SP7 were migrants into the area where they settled. However, LP3 settled in her natal area. Her mother RP2 displaced her neighbour, AP, and settled in AP's former territory leaving her own original territory vacant for her daughter, LP3.

All three females were photographically well-documented (Fig. 2) but only LP3 was recorded during all her life stages. We have photos of her as a 9/10 month old cub, as a sub-adult female, as a mother with cubs, and at the end of her life. LP3 was a relatively small tiger and highly aggressive. On one occasion a mature female with three cubs came out of the sub-optimal habitat in the hills to the south and tried to settle in the prime riverine habitat already occupied by LP3. The young tigress repulsed her and drove her back into the hills. LP3 produced five litters, but lost half of her 14 cubs.

Although SP7 only produced nine surviving offsprings, she was the most successful tigress as three of her daughters became resident breeding females. CP2 was still alive at the time of the last camera trapping season in 2015. She produced five litters containing 15 cubs, of which 9 survived. Her cubs were sired by four different males, EB, IB (x 2), KB2 and LB (Table 1).

Conclusions

CNP has a stable number of breeding females that occur at very high density and can raise their young in territories of <20 km². Mean territory size in this study was 16.6 km². Long-lived resident females giving birth to nearly five litters each during their lives characterise the population. Reproductive success is high. The limiting factor is the small amount of breeding habitat available in the park, which is almost entirely confined to riverine habitat, consisting of alluvial grassland, riverine forest, and lowland Sal forest. The majority of the park consists of unsuitable upland Sal forest.

In 1995, a tiger count of CNP results tabulated a total of 30 resident breeding females (DNPWC 2007). Given the degree of stability described over the last 20 years, one cannot expect any dramatic increase. More tigers require more prey and since the prey base in the park is in synch with the habitat, the only way to increase the prey is to increase the habitat. A big step in this direction has been the creation of the buffer zone BZ. Improved management of the BZ community forests has resulted in the creation of additional tiger habitat outside the park in the BZ.

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We thank Department of National Parks and Wildlife Conservation, and CNP for granting per-

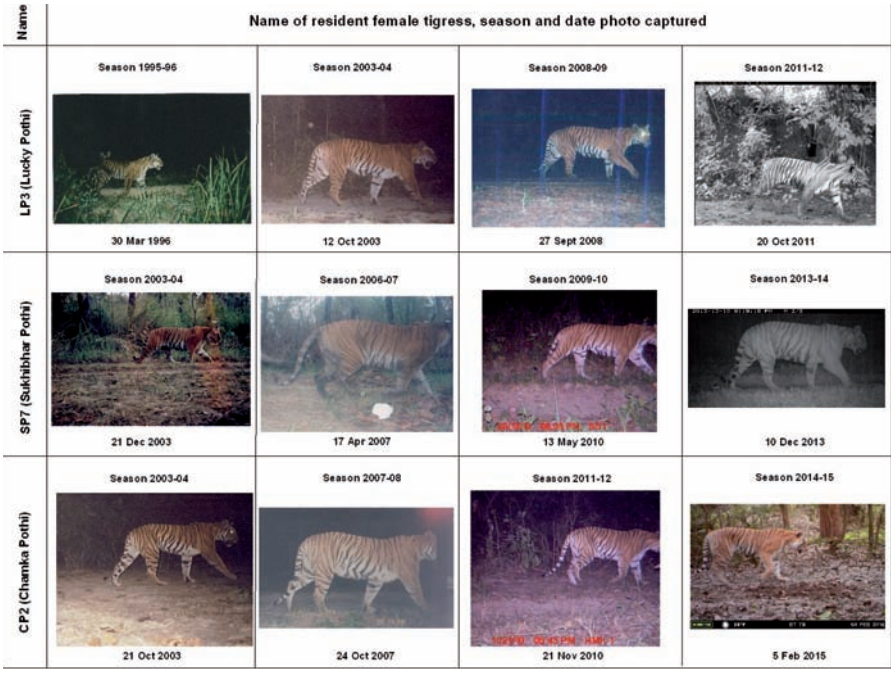

Fig. 2. Partial photo records of three long-lived breeding resident females during the camera trapping period.

Table 1. Litter size at detection and cub survival at dispersal of seven breeding resident females recorded more than ten seasons during the camera trapping in Chitwan National Park, Nepal.

Female	Male	Litter Year	Litter size	Survival	% Survival
AP	LB	1985	3	1	39%
	BB2	1987	3	2	
	DB	1989	2	0	
	NB	1990	2	2	
	NB	1992	3	2	
	NB	1996	2	0	
	NB	1997	3	0	
BP3	NB	1997	3	0	62%
	EB	1999	4	4	
	EB	2000	3	2	
	EB	2004	3	2	
CP2	EB	2002	4	3	60%
	IB	2005	4	4	
	IB	2008	3	0	
	KB2	2010	2	1	
	LB	2013	2	1	
LP3	NB	1998	2	0	50%
	EB	1999	2	2	
	EB	2001	4	3	
	EB	2004	3	0	
	IB	2006	3	2	
RP2	NB	1991	3	0	40%
	NB	1992	2	2	
	NB	1995	4	4	
	MB2	1998	3	2	
	MB2	2000	3	0	
SP7	EB	2001	4	3	75%
	EB	2005	2	0	
	IB	2006	3	3	
	DB2	2008	3	3	
TP	NB	1992	3	2	71%
	NB	1994	4	4	
	NB	1996	3	3	
	NB	1998	2	0	
	EB	1999	3	3	
	EB	2001	2	0	
Total			**104**	**60**	**58%**

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Supporting Online Material SOM Table T1a, b is available at www.catsg.org.

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SOM T1a. Radio and pugmark tracked breeding resident females from 1975 to 1995 seasons in Chitwan National Park, Nepal. Dash (-) indicates territories without resident female.

Method	Season	Territory 1	Territory 2	Territory 3	Territory 4	Territory 5	Territory 6	Total
Radio-Tracking	1975-76	-	BP	115	107	-	-	3
	1976-77	-	BP	115	107	-	-	3
	1977-78	-	BP	115	107	-	-	3
	1978-79	-	BP	115	107	-	-	3
	1979-80	BP	122	115	PP	118	-	5
Pugmark Tracking	1980-81	BP	122	115	PP	118	-	5
	1981-82	BP	122	115	PP	-	-	4
	1982-83	BP	122	115	JP	PP	-	5
	1983-84	BP	122	115	JP	PP	-	5
	1984-85	3TP > BP	AP	115	JP	PP	DP	7
	1985-86	3TP	AP	115	JP	PP	DP	6
	1986-87	3TP	AP	115	JP	PP	DP	6
	1987-88	3TP	AP	KP > 115	JP	PP	DP	7
	1988-89	LP	AP	KP	JP	BP2	DP > JP2	7
	1989-90	LP	AP	SP5	JP	JP2 > BP2	DP	7
	1990-91	DP2	AP	RP2	JP	-	DP	5
	1991-92	DP2	AP	RP2	JP	TP	JP2	6
	1992-93	DP2	AP	RP2	JP	TP	JP2	6
	1993-94	DP2	AP	RP2	JP	TP	JP2	6
	1994-95	DP2	AP	RP2	JP	TP	JP2	6

SOM T1b. Camera trapped breeding resident females from 1995 to 2015 seasons in Chitwan National Park, Nepal. Asterisk (*) indicates camera trapping not conducted.

Method	Season	Territory 1	Territory 2	Territory 3	Territory 4	Territory 5	Territory 6	Total
Camera Trapping	1995-96	TP2	AP	RP2	BP3 > JP	TP	JP2	7
	1996-97	TP2	AP	RP2	BP3	TP	KP3	6
	1997-98	TP2	RP2 > AP	LP3 > AP2	BP3	TP	KP3	8
	1998-99	TP2	RP2	LP3	BP3	TP	KP3	6
	1999-00	TP2	RP2	LP3	BP3	TP	KP3	6
	2000-01	CP2	TP2	LP3	BP3	TP > SP7	KP3	7
	2001-02	CP2	TP2	LP3	BP3	SP7	KP3	6
	2002-03	CP2	TP2	LP3	BP3	SP7	EP	6
	2003-04	CP2 > TP2	DP3 > NO4	LP3	BP3	SP7	EP	8
	2004-05	CP2	DP3	LP3	BP3	SP7	EP	6
	2005-06	*	*	*	*	*	*	-
	2006-07	*	*	LP3	*	SP7	*	-
	2007-08	NP2	CP2	LP3	BP5	SP7	CPP	6
	2008-09	NP2	CP2	LP3	BP5	SP7	CPP	6
	2009-10	NP2	CP2	LP3	BP5	SP7	CPP	6
	2010-11	NP2	CP2	LP3	BP5	SP7	CPP > KPP4	7
	2011-12	NP2	CP2	BP6 > LP3	BP5	SP7	DRP	7
	2012-13	*	*	*	*	*	*	-
	2013-14	NP2	CP2	BP6	BP5	SP7	DRP	6
	2014-15	NP2	CP2	BP6	BP5	vacant	DRP	5