Population structure and spatial distribution of the tiger (*Panthera tigris*, *Felidae, Carnivora*) in Southwestern Primorye (Russian Far East)

VICTOR S. LUKAREVSKIY¹,², SVYATOSLAV V. LUKAREVSKIY², SERGEY A. KOLCHIN³ & ALEXEY YU. OLEYNIKOV³

¹ Informational and Analytical Center of Support of Reserves, 123242, Moscow, Russia.
² Association of Wild Big Cats Research and Conservation (ABCR), Chernogolovka, Moscow Oblast, Russia.
³ Institute of Water and Ecology Problems, Far Eastern Branch, Russian Academy of Sciences, 680000, Khabarovsk, Russia.

Correspondence. E-mail: vlukarevsky@mail.ru

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Abstract
In 2011–2013, we surveyed the population structure, spatial distribution and the number of tigers in Southwestern Primorye (about 5000 km²). The total number of tigers, according to winter route census, DNA analysis and camera trapping was estimated at 24–25 adults and 6–7 cubs, belonging to four different litters. The location of tigers is mainly confined to areas difficult to access for people, and with a high density of ungulates. Tigers concentrated in the habitat strip bordering China, mainly comprising the 'Land of the Leopard' National Park. A few tiger tracks were recorded outside of protected areas and on hunting tenures.

Current methods for estimating tiger numbers needs critical reflection. Winter census by tracks in the snow is often largely influenced by subjectivity. The main reason for this is the large number of surveyors of various degrees of qualification and as a result the conflicting interpretation of track identification. In our opinion, the most objective results are obtained from a consistent survey of the territory by a limited number of specialists and daily adjustments of collected materials.

Precise and informative methods for determining the number and the structure of tiger populations are DNA analysis of biological samples combined with camera trap census. However, a number of significant drawbacks limits their widespread use: this method is labor-intensive and results in high project costs. In addition, weather conditions can greatly affect the preservation of DNA in the samples. There is a need to organize additional survey routes for installing camera traps and detecting of biological samples in order to register the tigresses with young, as they are behavior is often distinguished by a more secretive lifestyle. As a rule, female tigers with young avoid the main movement routes of adult tigers. These methods are expedient only in the smaller survey plots of model areas.

Key words: Amur tiger, camera trap, DNA analysis, *Panthera tigris altaica*, Southwestern Primorye, winter route census.
Introduction

The threats to conservation of the Amur tiger Panthera tigris altaica (Temminck, 1844) are destruction of habitat, fragmentation of the range, and a decrease in the number and genetic diversity within the population (Driscoll et al., 2009; Rozhnov et al., 2009; Yudin & Yudina, 2009). Significant changes in range structure and population size of this subspecies took place at the end of XIX – the first half of XX century (Silantyev, 1898; Baykov, 1925, 1927). The Amur tiger range was divided into a group of small foci, most of which subsequently disappeared (Kucherenko, 1983). Only two relatively isolated groupings have survived the Sikhote-Alin and the Southwestern Primorye group. The Sikhote-Alin grouping is the most significant in terms of area size and number (up to 80–90% of the present population). Henry et al. (2009), consider that the grouping of Southwestern Primorye is isolated, while P.A. Sorokin et al. (2016) showed that there exist rare migrations of tigers across the Razdolnaya River, and therefore there is an exchange between the two subpopulations.

Isolation of the current tiger group in Southwestern Primorye will affect this groups’ exclusive transboundary role in the restoration of tigers in the Northeastern China (Black Mountains, East Manchurian Mountains system) (Hebblewhite et al., 2015; Dou et al., 2016; Wang et al., 2016, 2018; Gu et al., 2018). However, without a detailed knowledge of spatial structure, demographic indicators and factors that influence to tiger distribution, it is almost impossible to manage a population of an endangered species. Identification of these parameters has become the main goal of our research.

Material and Methods

Study area. Our research in Southwestern Primorye in 2010–2013 covered almost the entire region (Figure 1). According to various estimates, potential tiger habitat occupies around 5000 km² (Pikunov et al., 2009). This territory includes the Kedrovaya Pad’ Reserve (160 km²), "Land of the Leopard" National Park (2650 km²), six hunting tenures (with a total area about 1300 km²), and borders in the north with "Poltavsky" Wildlife Sanctuary (about 900 km²), where tigers have not been recorded annually (Pikunov et al., 2009).

Tiger habitat in Southwestern Primorye includes various habitats: mountain slopes with highly dissected gorges, ravines, rock outcrops, plateaus and flat forested areas along the riparian zones with diverse plant communities, from coniferous-deciduous forests to pyrogenically transformed complexes, dominated by the Lespedeza bicolor. Most of the agricultural fields of former collective farms, which were destroyed after the breakup of the Soviet Union, are practically undeveloped and overgrown. They burn down almost every year. There is a border military zone along the border of Russia and China behind the line of engineering structures (ITS line = border fence) that is between several hundred meters to tens of kilometers wide, to which local residents are admitted rarely and with special permits only.

Route census. Traditionally, in the Russian Far East, estimation of the tiger population was based on analysis of measurements of the width of the palmar pad of the front paw, which varies in animals depending on sex and age (Abramov, 1961, 1965; Matyushkin & Yudakov, 1974). Individual identification of tigers by the footprint size subsequently became the counting basis for simultaneous census throughout all range and annual monitoring of tiger the population in Russia (Pikunov et al., 1983; Matyushkin et al., 1999; Miquell et al., 2006). Constant inaccuracies in interpretation of track information were quite common. Tracks identical in size and freshness could be attributed to different individuals, if linear distance between tracks according to the same criteria (Miquell et al., 2006), exceeded 4.7 km for females with cubs, 5–7.1 km – for single females, 7.5–9.6 km – for males. According to other sources (Order No. 63 of 15.03.2005 of the Ministry of Natural Resources of the Russian Federation), it was from 2.5–4 to 10–15 km for females, and from 3–4.5 to 12–18 km, for males. In most cases, determination of the total number of tigers for the surveyed area was given on the basis of expert assessment (Miquell et al., 2006; Riley et al., 2017).

In December 2011 – February 2012, in order to identify the spatial distribution of the tiger, we laid out a network of 96 survey routes, which passed sequentially from the north (from the Kazachka and Pavlinovka Rivers) to the south (to the Tsukanovka River) along the main river valleys and watersheds. In valleys of large rivers such as Nezhinka, Anan’evka, Amba, Barabashevka, Ryanzovka and plateau-like watersheds, where there were roads, routes were mainly examined by car or snowmobile. Routes surveyed on foot were placed along ridges of the mountain ranges and in small river valleys. Their total length was...
1408 km, and they covered almost the entire territory of Southwestern Primorye (Figure 1). Each route was chosen with the maximum likelihood of encountering tiger tracks in mind. This decision was based on the peculiarities of expected tiger behavior in choosing movement paths along the guiding lines of relief (Matyushkin, 1977; Yudakov & Nikolaev, 1987).

Figure 1. Census routes and places of encounters of tiger tracks in study area: blue dots, during the expedition surveys; red dots, during monitoring of the model site.

Route census was started in the first decade of December, ten days after snowfall. Stable frosty weather persisted throughout the winter – night temperatures dropped to $-25 \degree C$, and daytime temperatures dropped to $-5 \degree C$. 

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On the routes, all signs of tiger presence were recorded: footprints, scrapes on the ground, urinary points, scats and hairs. Collection of biological samples (hair, scat and blood) was organized, which were fixed in accordance with the instructions for further DNA studies. During field identification of individual track size (with an accuracy of +/- 2–3 mm), gender, presence of cubs, direction of movement, and freshness of the track were registered. For each location where signs of tiger activity were found, geographic coordinates determined by a GPS navigator, were also recorded.

The general scheme of the route layout was as follows. Every day we chose 3–5 parallel routes. Each of them had a linear direction and usually covered a river valley, slope and watershed ridge. The length of the route was on average 5–10 km, and the distance between routes, about 1.5–2 km. Thus, an area of about 50 km² was daily surveyed. In addition, each set of tracks encountered were followed to detect biological samples. All results obtained during the day were discussed in the evening. The number of tigers and their movement patterns in the surveyed area was determined.

From February 25 to March 1, 2012, as a part of the annual monitoring of the Amur tiger population, we surveyed the Borisovskoe Plateau (Figure 1). On 14 routes, seven of which were conducted from a vehicle, three – by foot and four – mixed, with a total length of 251 km, 34 sets of tiger tracks were recorded. Monitoring data was used to analyze the distribution of tigers after the end of the hunting season (February 20), as well as for comparison with data we had obtained earlier for this site during continuous route "scanning" of the territory.

**DNA analysis.** For individual identification of tigers, we also used the DNA method for analyzing biological samples (excrements, blood, and hair; Rozhnov et al., 2012, Sugimoto et al., 2012). Bioassays were collected in winter 2010/11 (n = 15) and 2011/12 (n = 142). Low air temperatures during the collection periods contributed to the safety of samples. Almost all collected scats were suitable for DNA analysis.

Taking into account that DNA analysis does not allow for age determination, we also recorded the track size of tigers, other clues such as the presence of signs of females with cubs or a mating pair and the associated behavior (marking, mating, etc.). DNA analysis allows for the determination of the degree of the relationship between animals. Individuals are considered related, if their genetic profile matched at least one allele of each locus of the studied DNA segment. Individuals with the same genetic profile at all loci and differing in few alleles only, considered close relatives.

**Camera trap census.** Between November 2011 and March 2013, we installed wildlife trail cameras in order to count leopard numbers in a model area of 503 km² (Lukarevsky & Lukarevsky, 2019). Tigers were also recorded by the same cameras. The main travel routes of tigers and leopards, as well as the camera placements, were different. Tigers prefer the forest roads and trails on plateau-like ridges and river valleys, while leopards move more often along narrow ridges and steep rocky slopes (Korkishko, 1986). Long-term operation of camera traps made it possible to obtain information about the location of tigers in this area. Independent individuals were considered residents, if they were registered in the same area for at least three months. Young females from dispersed litters were also referred to as residents, because unlike males, they usually do not leave the maternal home range and settle nearby (Goodrich et al., 2005).

Identification of individual tigers was achieved by comparing the pattern and shape of stripes on the body, which is different for each animal (Schaller, 1967; Karanth, Nichols, 1998). Sex and age of animals has been determined by the apparent primary sex characteristics, and body shape and size.

We used data of the camera traps as additional information to refine and compare the results, obtained by different methods.

**Application of satellite telemetry.** In order to study the spatial distribution and structure of home ranges, the capture and tagging of tigers with Sirtrack collars (New Zealand) with GPS_Argos satellite radio beacons and VHF transmitters was organized. For these purposes the area bordering with China was primarily surveyed which included Kraunovka, Borisovka, Anan’evka, Gryaznaya and Amba Rivers. In 2010/11, five tigers (four females and a male) were caught and equipped with transmitters in this area. Capture was performed using Aldrich foot snares, followed by drug immobilization (Goodrich et al. 2001; Frank et al. 2003). We have previously described the method for analyzing satellite telemetry data and the nature of habitat use by tigers (Rozhnov et al., 2011; Hernandez Blanco et al., 2011). The boundaries of home ranges of the marked tigers were determined by the minimum convex polygon method (Hayne, 1949), including 100
and 95% of locations. Using the 95% method makes it possible to exclude occasional exits of individuals outside of their usual home ranges.

By applying the minimum convex polygon method (Hayne, 1949) with the inclusion of 100% of locations, DNA analysis of biological samples and camera trap information, it was possible to construct the home ranges of a few of the marked tigers. They provided representative material for comparison and understanding of spatial distribution of individuals relative to each other.

Results

Distribution of tiger tracks. Distribution of tiger in Southwestern Primorye during 2011/12 winter season was uneven. The largest number of tracks was found near the ITS line (border fence), along the border with China. In the northern part, tracks were concentrated in the border strip up to the ITS line: in the upper part of Kraunovka, Listvennichnaya, Medveditsa, and Borisovka Rivers watersheds and in the Nezhinka River watershed (territory of "Land of the Leopard" National Park; Figure 2, polygon 1). In the border zone – behind the ITS line: from Mount Polkovnitsa in the south to Mount Podkolochnaya in the north (confluence of the Kazachka and Granitnaya Rivers). In the Malaya Kazachka and Pavlinovka Rivers watersheds, only rare tracks of mainly transient tigers were recorded. Here tigers crossed the territory in a straight line along the unpaved roads.

In total, at least eight individuals were recorded on this area in winter 2011/12, including three adult females, three males and two subadult tigers. In upstream of Listvennichnaya River, a mating pair was recorded.

South of Borisovka River, in the upper reaches of the Nezhinka, Anan’evka, Gryaznaya and Amba Rivers, the distribution of tiger tracks was similar to that in the northern sites in the Kraunovka and Medveditsa Rivers watersheds. On both sides of the ITS line they were detected evenly (Figure 2, polygon 2). In the northern part of the area, occupied by this group, there were tracks of two females with cubs 3.5–4 and 6.5–7.5 months old (the width of the palmar pad of cubs was 4.5–5 and 6.5–7 cm, respectively), as well as of two adult single females equipped by collars, one of which was "Svyazistka" (found in upper reaches of Gryaznaya and Anan’evka Rivers), who was in estrus and was actively marking the territory and tigress "Albara" (Amba River watershed). There were three adult males in this area as well. In the upper reaches of the Amba River, on both sides of the ITS line, the occurrence of tiger tracks was at a maximum.

In the watersheds of Barabashevka and Narva Rivers the distribution of tigers changed significantly (Figure 2, polygon 3). Up to the ITS line, there were only tracks of transient tigers, traveling west from Kedrovaya Pad’ Reserve. In the border area, between the ITS line and the border with China, the number of tiger tracks increased. A somewhat different picture was noted in area of Siniy Utyos Mountain. Tiger tracks here were encountered evenly on both sides of the ITS line. In the Barabashevka–Narva watershed, track distribution was widespread, but the presence of tigers was also only of a transitory nature. Tigers moved between the Kedrovaya Pad’ Reserve and the border strip. A female with two cubs, an adult female and an adult male were recorded within the territory of the Reserve. Tracks of another female and an adult male were recorded in the upper reaches of the Narva River. In the border zone, at the source of Barabashevka River, tracks of an adult male were found. In this area, at least three adult females, two adult males and an unknown subadult tiger were registered.

In the watershed of Poima River and to the south of it (watersheds of the Vinogradnaya, Dozornaya and Tsukanovka Rivers), tiger tracks were common mainly in the border zone. Here they were found on all routes in the upper reaches of these rivers. On the three hunting tenures "Fauna", "Slavyanskoe", and "Khasanskoe", tigers were almost completely absent. A total of one adult female and two males were recorded in this area (Figure 2, polygon 4).

The total number of tigers obtained from analysing track information along the routes in Southwestern Primorye, was 30–32 individuals, among which 24–25 were adult and independent subadult animals, while 6–7 of the registered tigers were cubs.

Based on the topography of tracks, their freshness and size, seven tigers were identified in the Borisovskoe Plateau monitoring site. Four of those were females, two males, and one cub (Figure 1), which corresponded well to the data obtained during our continuous route "scanning" of the area. During track monitoring, cubs with a track width of 4.5–5 cm were not recorded. Only a print of a single cub with a width of 7.0 cm was found, and this was in the absence of female tracks in the vicinity. It can be assumed that one
of the previously recorded females, who was with cubs at the time, has died. This was indirectly confirmed by the discovery in February to early March 2012 of two extremely emaciated orphaned cubs in Zolotushka and Borisovka River watersheds. It cannot be ruled out that this litter belonged to a third female for this site, which was previously not registered.

Figure 2. Distribution of tiger tracks in Southwestern Primorye.
**Relationship between tigers according to DNA identification.** Of the 167 collected samples, DNA was extracted from 87. Their topographic distribution, in addition to individual identification, indicates the presence of three relatively isolated tiger groupings in Southwestern Primorye (Figure 3). Below are brief characteristics of each grouping.

![Figure 3. Relationship between tigers according to DNA identification.](image-url)
1. Northern grouping (A). It is the largest grouping, which includes seven females and four males. While all females are related to each other, among the males there are completely unrelated individuals as well as close relatives.

2. Central grouping (B). Includes two unrelated females and three males. Females of this grouping are significantly distant from females of the other groupings, and probably have no kinship with them.

3. Southern grouping (C). Represented by one female and one male. According to genetic profile, one of the males of the northern grouping is a close relative, most likely being the son of the female from the southern group.

**Relationship between tigers according to photo-ID results.** With the use of camera traps 11 tigers were recorded on the model site (Lukarevsky & Lukarevsky, 2019) from January 18, 2012 to December 14, 2013 (Table 1). Five residents (two males and three females), two cubs older than a year, three males sighted only a few times, and a subadult individual of unknown sex (Figure 4).

**Table 1. Registration of tigers with camera traps from November 2011 to March 2013.**

| Code of individual | Sex   | Locations’ number | First meeting | Last meeting |
|--------------------|-------|-------------------|---------------|-------------|
| PT001              | male  | 8                 | 18.01.2012    | 21.01.2013  |
| PT002              | female| 4                 | 19.02.2012    | 18.10.2012  |
| PT003              | male  | 2                 | 13.02.2013    | 13.02.2013  |
| PT004              | male  | 22                | 03.03.2012    | 23.01.2013  |
| PT005              | female| 22                | 10.03.2012    | 14.12.2012  |
| PT006              | female| 25                | 29.07.2012    | 31.10.2012  |
| PT007              | male  | 3                 | 28.09.2012    | 29.09.2012  |
| PT008              | male  | 3                 | 22.01.2013    | 02.02.2013  |
| PT009              | unknown| 5               | 02.05.2012    | 23.08.2012  |
| PT010              | unknown| 1               | 22.08.2012    | 22.08.2012  |
| PT011              | unknown| 2               | 08.03.2012    | 22.03.2012  |

According to the topography and the frequency of how often tigers were registered, the core area of this grouping is located in the upper reaches of the Narva River and in the interfluve of the Narva and the Barabashevka Rivers. Three resident individuals have been registered here: one adult male and two adult females. Two cubs more than one-year-old accompanied one female. The two females’ home ranges overlapped. In the winter of 2012–2013, three adult males were recorded in the study area.

In the northern part of the study site, a subadult tiger of an unknown sex, and an adult female and a male were registered (the two latter animals were equipped with satellite transmitters). According to the documented topography as well as the data from satellite telemetry, the home ranges of these tigers was located to the north. A subadult individual was also registered here.

**Satellite telemetry results.** Satellite telemetry data provide an idea of configuration and structure of a tigers’ home range (see Hernandez-Blanco et al., 2015, Figure 5). At the same time, GPS- and radio tracking does not allow assessing the social structure of the population in the presence of unmarked individuals in the study area. In addition, only 1–3 tigers could be caught in a single season, while the duration of the transmitters’ battery averaged only 147 days for five tigers, which is insufficient to assess habitat use.

“Svyazistka”, PT017F – female, 2–3-year-old, was caught in September 2010. During the transmitter’s operation period (188 days), locations were obtained which probably reflect incomplete home range data, character plus movement dynamics of young animal. Especially because this tiger was later (in December 2011) recorded 5 km from its previous most extreme southern location (Hernandez-Blanco et al., 2015).

“Vorovka”, PT016F – female over 10 years old, was caught in October 2010. The home range, modeled on the basis of GPS-locations, acquired over a period of 240 days, was about 282 km².
“Griaznulya”, PT019M – male over 10 years old, was caught in May 2010. The home range, modeled on the basis of locations, acquired over a period of 136 days, was about 634 km².

“Elduga”, PT020F – female over 12 years old. Recorded with camera traps since 2002 and at the time of capture in May 2010, she had three cubs older than one and half years (Rybin A.N., personal communication). Home range, modeled on the basis of locations for a period of over 113 days, was about 190 km².

“Albara”, PT022F – female, no more than five-year-old. At the time of capture in October 2011, she was nursing cubs. According to DNA analysis (Rozhnov et al., 2015) she was directly related to female “Elduga” and male “Griaznulya”, and probably is their daughter. Home range, modeled on the basis of locations, for a period of over 61 days, was about 83 km².

Figure 4. Distribution of tigers in the Amba, Barabashevka, and Narva River watersheds according to photo-identification results.
Using the route survey of the area in the winter of 2011–2012, DNA analysis of biological samples and camera trap data, the total number of tigers we counted, was 25–26 adults and 8–9 cubs from four litters. Among them, there were 13–14 females, 10–11 males, and at least three individuals of unknown sex. It cannot be ruled out, that some of the younger animals, avoiding travel on main trails and roads, as well as some of the adult males in the northern part of the region were not identified. This could have led to an underestimation of the total number. In 2007, only 11–13 individuals (four males, four females, and 3–5 individuals of unknown sex and age) were identified by the traditional winter tracking method in the same area (Pikunov et al., 2009). Later estimation of tiger numbers in this region, which was based on monitoring with camera traps, showed results that were similar to our data (Matiukhina et al., 2016).

Generally, tiger track distribution shows that animals gravitate to inaccessible areas that are little visited by humans with a high density of ungulates in the border zone and inside the National Park. Within
the hunting tenures, tracks of tigers were mainly recorded near the boundaries of protected areas, in upper reaches of watersheds and far away from existing roads. In areas where humans hunt ungulates regularly, tiger tracks were sporadic, while in the southern part of the region, dominated by humans, they were completely absent (Figure 1).

The results of DNA analysis combined with photo-identification show the existence of the areas with an increased density of tigers, especially in the northern part of study area.

According to satellite telemetry data, tiger home range size in the Southwestern Primorye is the smallest within the home range of this subspecies (Hernandez-Blanco et al., 2015), which reflects high population densities of the main prey species such as wild boar (Sus scrofa) and sika deer (Cervus nippon) (Hojnowski et al., 2012). It should be noted that the abundance of secondary and summer prey, like Siberian roe deer (Capreolus pygargus), Asiatic badger (Meles leucurus), Asiatic black bear (Ursus thibetanus), raccoon dog (Nyctereutes procyonoides), and Manchurian hare (Lepus mandshuricus) is also important for distribution and density of tiger population. High diversity and density of prey ensures the unhindered implementation of the tiger's hunting techniques, which differ from individual to individual by sex, age, and family groups (Yudin & Yudina, 2009). A preliminary scat analysis, collected during the winter season, showed differences in composition of prey between females with cubs and solitary individuals. The diet of the former is dominated by wild boar and sika deer, while solitary tigers hunt the secondary prey species. We believe that different strategy of using food resources promotes the high tiger density. In addition, a high degree of social tolerance with a wide overlap of home ranges can also be maintained due to the predominance of related females in the grouping. A relative isolation of the Southwestern Primorye from Sikhote-Alin, the low quality of the tiger habitat in the adjacent China, and the high level of disturbance are all factors that are likely influencing the social organization of tigers in study area. Such factors can hinder the natural dispersal and breadth of spatial movements of young individuals. The creation of a number of specially protected areas and the improvement of the protection of the species contributed to an increase in frequency of visits and permanent use of tigers on the Chinese side bordering Southwestern Primorye, with the Changbai Mountains (Dou et al., 2016; Wang et al., 2016; Xiao et al., 2016; Wang et al., 2018).

We believe that the estimate of tiger numbers based on the current monitoring program by winter tracking is mostly subjective. The method is based on the metric and visual identification of tracks in the snow. The criteria for interpreting the gained information is very ambiguous and often contradictory. The results are ultimately based on the personal judgment (expert review) of the project coordinator (Riley et al., 2017). Since a large number of the field personnel of various qualification are involved in this census process, each of whom is prone to making a mistake, the total number of tigers obtained can differ significantly from an actual number (Pikunov, Yudin, 2015).

According to our data (Hernandez-Blanco et al., 2011), tigers are able to move a considerable distance during the day. This fact makes it possible that twice other researchers in an adjacent area count the same individuals’ tracks. For example, in February 2018 in the Durmin River watershed (model plot “Khorskiy”, Central Sikhote-Alin), an adult female made a transition during the night with a linear distance of about 20 km, and in February 2020, an adult male moved at least 30 km during the night (our unpublished data). Another example showing a wide range of movement, was an adult male (M6), recorded in two locations within one month, with the linear distance between the two spots exceeding 100 km (Figure 3). Research in recent decades suggests that several tigers of the same sex may be present in the same area at the same time (Goodrich et al. 2005; our unpublished data). Within the Ussuriysky Reserve, we simultaneously recorded in the same area the tracks of at least three adult males with all of them virtually showing the same track size. All three tigers were equipped with satellite transmitters and, in addition, were recorded by camera traps.

Only tracks of adult tigers of different sex can be identified with a high degree of reliability. Individual identification through track size is often very difficult for same-sex adults. Male cubs older than one year have footprint size close to or larger than those of adult females. It is also known that weather conditions, primarily temperature and solar exposure, can have a significant effect on the tracks’ shape and size, which can change in a short period of time (Yudin, 2005, 2006). We believe that an adequate assessment of population size by tracks, entrusted to a large group of individual researchers, is a difficult and not always solvable task. Only a consistent survey of an area, conducted by a team of qualified specialists with daily discussions and comparison of collected information, can yield objective results.

DNA analysis also has its limitations. If collection and storage method of a sample is violated, or if a sample is exposed for a certain amount of time in the open and under windy conditions, high temperature and
intense insolation, it is not always possible to extract the DNA from it. This could lead to an underestimation of tiger numbers. In one area where the matrix of camera traps was located and biosamples of cubs collected, it was impossible to isolate DNA later. During the same period, camera traps installed in two locations, captured a female with one cub (female) about 1.5 years old, which were not identified by the DNA analysis. Within the same area in Kedrovaya Pad' Reserve, tracks of a female with two cubs were recorded, but they were also not detected by DNA analysis.

In Southwestern Primorye in winter 2011–2012 four females with cubs were recorded (three of them were found through tracking, and only one via camera trap). Another lactating female was captured and tagged with a satellite transmitter in October 2011, but in the winter of 2011/12 no tracks of cubs was observed.

For the detection and collection of high quality biological samples from cubs who do not always stay with their mothers, it is necessary to lay special monitoring routes and when signs are found, conduct long tracking sessions.

The method of DNA identification, due to its labor intensiveness and the high material costs involved (Riley et al., 2017), is unsuitable for regular monitoring of populations. However, this method has high instrumental capabilities to study the social structure of tigers, especially together with methods of snow tracking and photo-identification.

Camera trap census is also a highly accurate method for the individual identification of tigers. When applying this method, subjectivity in interpreting the collected data is virtually excluded, while the results allow external experts for reasons of accuracy to go over the data again.

The use of camera traps in comparison with the traditional snow tracking method in the Sikhote-Alin’ Reserve revealed a population density that was twice higher than the number obtained by the second method for the southern part of the reserve, where numbers of tigers are the highest (Soutyrina et al., 2013).

The camera trap method, due to high labor and material costs (Riley et al., 2017), is more suitable for use in small study areas, limited in size by protected areas and hunting tenures. A significant downfall of this method is the extremely rare deduction of tiger cubs by camera traps, noted in the previous surveys (Soutyrina et al., 2013; Matiukhina et al., 2016) and associated with the rather secretive lifestyle of family groups. Females with cubs, for example, rarely visit objects of intra- and interspecific indirect communication such as mark trees (Kolchin & Soutyrina, 2012) that are traditionally prime locations for setting up camera traps.

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